POST GRADUATE DEPARTMENT OF ANALYTICAL CHEMISTRY COURSE STRUCTURE FOR ACADEMIC YEAR 2024-2025

(Total Credits: 80)

Semester I (20 credits)

Course Code	Course Type	Course Title	Credits	Contact hours/week		
				L	**T**	**P**
PGMP-CHE-DSC-401	Discipline Specific Core (DSC)	General Inorganic Chemistry	4	4	0	0
PGMP-CHE-DSC-402	Discipline Specific Core (DSC)	General Physical Chemistry	4	4	0	0
PGMP-CHE-DSC-403	Discipline Specific Core (DSC)	Fundamentals of Organic Chemistry	4	4	0	0
PGMP-CHE-DSC-404	Discipline Specific Core (DSC)	Laboratory Course in Physical Chemistry	2	0	0	4
PGMP-CHE-DSC-405	Discipline Specific Core (DSC)	Laboratory Course in Organic Chemistry	2	0	0	4
	Total Credits for Discipline Specific Core subjects		**16**			
	Discipline Specific Elective (DSE)	Discipline Specific Elective I	2	2	0	0
	Discipline Specific Elective (DSE)	Discipline Specific Elective II	2	2	0	0
	Total Credits for Discipline Specific Elective subjects		**4**			
Total Minimum Credits for Semester I - 20						
	List of Discipline Specific Electives I and II					
PGMP-CHE-DSE-401	Reaction Mechanisms in Organic Chemistry		2	2	0	0
PGMP-CHE-DSE-402	Topics in Physical Chemistry		2	2	0	0
PGMP-CHE-DSE-403	Diffraction Methods		2	2	0	0

Semester II (20 credits)

Course Code	Course Type	Course Title	Credits	Contact hours/week		
				L	**T**	**P**
PGMP-CHE-DSC-406	Discipline Specific Core (DSC)	Spectroscopy in Chemistry	4	4	0	0
PGMP-CHE-DSC-407	Discipline Specific Core (DSC)	Fundamentals of Chemical Analysis	4	4	0	0
PGMP-CHE-DSC-408	Discipline Specific Core (DSC)	Spectral Methods of Analysis	4	4	0	0
PGMP-CHE-DSC-409	Discipline Specific Core (DSC)	Laboratory Course in Analytical Chemistry	2	0	0	4
PGMP-CHE-DSC-410	Discipline Specific Core (DSC)	Laboratory Course in Inorganic Chemistry	2	0	0	4
	Total Credits for Discipline Specific Core subjects		**16**			
	Discipline Specific Elective (DSE)	Discipline Specific Elective III	2	2	0	0
	Discipline Specific Elective (DSE)	Discipline Specific Elective IV	2	2	0	0
	Total Credits for Discipline Specific Elective subjects		**4**			
Total Minimum Credits for Semester II – 20						
	List of Discipline Elective III and IV:					
PGMP-CHE-DSE-404	Topics in Inorganic Chemistry		2	2	0	0
PGMP-CHE-DSE-405	Reagents in Organic Synthesis		2	2	0	0
PGMP-CHE-DSE-406	Bio analytical Chemistry		2	2	0	0

Semester III (20 credits)

Course Code	Course Type	Course Title	Credits	Contact hours/week		
				L	**T**	**P**
	Discipline Specific Elective (DSE)	Discipline Specific Elective V	2	2	0	0
	Discipline Specific Elective (DSE)	Discipline Specific Elective VI	2	2	0	0
	Discipline Specific Elective (DSE)	Discipline Specific Elective VII	2	2	0	0
	Discipline Specific Elective (DSE)	Discipline Specific Elective VIII	2	2	0	0
	Total Minimum Credits for Discipline Specific Elective subjects		**8**			
	Discipline specific research Electives (DSRE)	Research Specific Elective-I	4	4	0	0
	Discipline specific research Electives (DSRE)	Research Specific Elective-II	4	0	0	8
	Total Minimum Credits for Discipline Specific Research Elective subjects		**8**			
	Generic Elective (GE)	Generic Elective I *(From other Department)*	2	2	0	0
		Generic Elective II *(From other Department)*	2	2	0	0
	Total Minimum Credits for Generic Elective subjects		**4**			
Total Minimum Credits for Semester III - 20						
	List of Discipline Specific Electives V VI VII and VIII					
PGMP-CHE-DSE-501	Calibrations and Validation		2	2	0	0
PGMP-CHE-DSE-502	Methods of Analysis		2	2	0	0
PGMP-CHE-DSE-503	Advanced NMR Spectroscopy		2	2	0	0
PGMP-CHE-DSE-504	Separation Techniques		2	2	0	0
PGMP-CHE-DSE-505	Quality Assurance and Quality Control in Analytical Chemistry		2	2	0	0
PGMP-CHE-DSE-506	Chemometrics		2	2	0	0
	List of Discipline Specific Research Electives I and II					
PGMP-CHE-DSRE-501	Research Methodology & Academic writing		4	4	0	0
PGMP-CHE-DSRE-502	Experiments in Analytical Chemistry		4	0	0	4
PGMP-CHE-DSRE-503	Experiments on Analytical Instrumentation		4	0	0	4
	List of Generic Elective (For M.Sc. Chemistry Students)					
	To be opted from other PG departments		4			
	List of Generic Elective I and II (To be offered by M.Sc. CHEMISTRY)					
PGMP-CHE-GE-501	Food chemistry and Nutrition		2	2	0	0
PGMP-CHE-GE-502	Environmental Chemistry		2	2	0	0
PGMP-CHE-GE-503	Application of Chemistry in Everyday Life		2	2	0	0

Semester IV (20 credits)

Course Code	Course Type	Course Title	Credits	Contact hours/week		
				L	**T**	**P**
	Discipline specific research Electives (DSRE)	Research Specific Elective-III	2	2	0	0
	Discipline specific research Electives (DSRE)	Research Specific Elective-IV	2	2	0	0
	Total Minimum Credits for Discipline Specific Research Elective subjects		**4**			
PGMP-CHE-DSR/I-501	Discipline Specific Research or Internship		**16**			
Total Minimum Credits for Semester IV - 20						
	List of Discipline Specific Research Elective subjects III and IV					
PGMP-CHE-DSRE-504	Synthesis of Inorganic Materials		2	2	0	0
PGMP-CHE-DSRE-505	Catalysis		2	2	0	0
PGMP-CHE-DSRE-506	Applied Organic Chemistry		2	2	0	0
PGMP-CHE-DSRE-507	Nanomaterials		2	2	0	0

POST GRADUATE DEPARTMENT OF ANALYTICAL CHEMISTRY SYLLABUS FOR ACADEMIC YEAR 2024-2025

SEMESTER I

Course Code: PGMP-CHE-DSC-401
Course Title: General Inorganic Chemistry
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

1. To enable students to know about the atomic structure and different properties of atom and elemental chemistry
2. To enable students to study the fundamentals of Inorganic Chemistry

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Recall fundamental concepts related to chemistry of boron and its derivatives.
CLO2: Explain the principles of molecular symmetry, matrix representations of symmetry operations, and predict the symmetry properties of molecules.
CLO3: Analyze and assess the synthesis, structure, bonding, and important reactions of various organo-transition metal complexes
CLO4: Apply the principles of molecular structure and bonding to predict the geometry of molecules using different theory for a variety of molecular configurations.
CLO5: Evaluate and compare the characteristics of metals, alloys, and ionic solids

MODULE I: Atomic Structure, Molecular structure and Bonding 15 Hours

Atomic Structure- Recapitulation; Atomic parameters: Atomic and ionic radii, ionization energy, electron affinity, electro negativity (Pauling, Allred-Rochow definition, Mulliken definition); Molecular structure and bonding: Lewis structures and bond properties; the VSEPR Model- Walsh diagrams (tri and penta-atomic molecules); Valence bond theory- hydrogen molecule, homonuclear diatomic molecules, polyatomic molecules, hybridisation; Molecular orbital theory: approximations of the theory (LCAO-MO), bonding and anti-bonding orbitals, homonuclear and heteronuclear diatomic molecules.

MODULE II: Molecular Symmetry and Solid-State Chemistry 15 Hours

Molecular symmetry, representation of symmetry operation as matrices. Definition of groups, set of symmetry operations of molecules satisfying the condition of point groups. Representation, basis of representation, reducible and irreducible representation.The great orthogonality theorem, character tables.

Packing of spheres: Unit cell and description of crystal structure; close packing of spheres; holes in closed-packed structures; structure of metals: polytypism, structures other than closed packed; polymorphism of metals, atomic radii of metals, alloys; Ionic solids: characteristic structures of ionic solids, the rationalization of structures, the energetics of ionic bonding, consequences of lattice enthalpy; defects in crystals.

MODULE III: Boron and Coordination Chemistry 15 Hours

Boron - introduction, borane, carboranes, borazine and its derivatives; halides of boron. Coordination Chemistry- Recapitulation; shapes of coordination compounds; bonding in coordination compounds- valence bond theory and crystal field theory; magnetism in coordination compounds; colour of coordination compounds; reaction mechanisms of transition metal complexes (in brief).

MODULE IV: Bioinorganic and Organometallic Chemistry 15 Hours

Bioinorganic Chemistry- metal ions in biological systems; deficiency of trace metal ions (Fe, Zn, Cu and Mn); proteins and their functions- Heme proteins, synthetic oxygen carriers, electron transfer proteins-cytochromes, metalloproteins as enzymes-carboxypeptidase and Vitamin B12 coenzyme; chlorophyll and its use in photosynthesis.

Organometallic Chemistry- Definitions, classification of organo-transition metal complexes; the EAN, 18-electron and 16-electron rules; synthesis, structure, bonding and important reactions of metal carbonyls, metal nitrosyls, dinitrogen and dioxygen complexes.

REFERENCE BOOKS:

Mandatory:

1. Inorganic Chemistry; D. F. Shriver and P. W. Atkins; 5th Edition, Oxford University Press
2. Concise Inorganic Chemistry, J. D. Lee; 5th Edition, Chapman and Hall

Supplementary:

1. Principles of Solid State Chemistry, H. V. Keer; New Age International Ltd, New Delhi
2. Inorganic Chemistry: Principles of Structure and Reactivity, J. E. Huheey, E. A. Kiter; 4th Edition, Addison-Wesley Publishing House
3. Basic Inorganic Chemistry, F. A. Cotton and G. Wilkinson; 6th Edition, Wiley Eastern, New Delhi
4. Chemical Applications of Group Theory, 2nd Edition, F. A. Cotton, Wiley Eastern Ltd.
5. Symmetry and Spectroscopy of Molecules; K. Veera Reddy, New Age International, (2011).
6. Group Theory in Chemistry; M. S. Gopinathanan and V. Ramakrishnan, Vishal Publishing Co. (2007)
7. Nature of Chemical Bond, L. Pauling; 3rd Edition, Cornell University Press
8. Solid State Chemistry, D. K. Chakrabarty; 2nd Edition, New Age Publishers
9. Coordination Chemistry, D. Banerjea, Tata McGraw-Hill, New Delhi
10. Solid State Chemistry and Its Applications, A. R. West; John Wiley and Sons, Singapore
11. Basic Inorganic Chemistry, F. A. Cotton and G. Wilkinson; 3rd Edition, John Wiley and Sons, Singapore

WEB REFERENCES:

1. https://byjus.com/jee/atomic-structure/
2. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_(Inorganic_Chemistry)/Coordination Chemistry
3. http://www.chemistry.wustl.edu/~edudev/LabTutorials/naming_coord_comp.html
4. https://www.toppr.com/guides/chemistry/coordination-compounds/bonding-in-metal- carbonyls/

Course Code: PGMP-CHE-DSC-402
Course Title: General Physical Chemistry
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

1. To enable students to understand the mechanism of reactions in nature
2. To enable students to understand the concept of micro-objects and its solutions with the help of quantum chemistry
3. To provide students with detail knowledge about thermodynamics and equilibrium systems

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Propose the mechanism of different reactions taking place in the environment.

CLO2: Interpret the significance of internal energy, enthalpy, entropy, and free energy in thermodynamic processes.

CLO3: Apply the Hückel Molecular Orbital theory to analyze and predict molecular properties for conjugated molecules

CLO4: Analyze critically the role of various factors in achieving desired outcomes in electrochemical processes.

MODULE I: Quantum Chemistry 15 Hours

Historical development of quantum theory, principle of quantum mechanics, wave particle duality, uncertainty principles; operators, functions, Eigen value equations; Schrodinger equation, application to simple system viz. free particle, particle in one dimensional, two dimensional and three dimensional box (quantization, separation of variables, degenerate wave functions); Hydrogen like atoms, Schrodinger equation and its solutions; atomic orbital wave function and interpretation; Hückel MO theory, secular equations, secular determinant, delocalization energy, charge density, pi-bond order, free valence, applications to C_2H_4,C_3H_5(radical), C_4H_6, C_4H_4, C_6H_6, C_6H_8.

MODULE II: Thermodynamics 15 Hours

Thermodynamic properties- state and path properties; intrinsic and extrinsic properties, exact and inexact differentials, internal energy, enthalpy, entropy, free energy and their relations and significances; Gas laws, Real gases, Boyle temperature; Maxwell's relation; thermodynamic equations of state; Joule-Thomson effect; Joule-Thomson coefficient for van der Waals' gas, Joule-Thomson effect and production of low temperature; adiabatic demagnetization, inversion temperature; third law of thermodynamics; need for the third law; Nernst heat theorem, apparent exceptions to third law, application of third law, use of thermodynamic functions E, H, S and G in predicting direction of chemical change; entropy probability and its relation to partition function; numerical on calculation of entropy.

MODULE III: Chemical Kinetics 15 Hours

General introduction to various types of order of reaction including fractional order; comparative study of transition state and collision state theory (derivation not required); Eyring equation; free radical reactions, complex reactions like decomposition of acetaldehyde and ozone; reaction between H2 and Br2; homogeneous, heterogeneous, and acid-base catalysis; elementary enzyme reactions; autocatalysis and oscillatory reaction.

MODULE IV: Electrochemistry and Phase equilibria 15 Hours

EMF series, decomposition potential and overvoltage, electrogravimetry, basic principles, completeness in deposition; separation with controlled potentials; constant current electrolysis; composition of electrolyte; potential buffers; physical characteristics of metal deposits; electroplating and electro less plating; electro synthesis; potentiostatic and dynamic related numerical problems; Phase rule- discussion of two component systems forming solid solutions with and without maximum or minimum in freezing point curve; systems with partially miscible solid phases; three component systems- graphical representation; three component liquid systems with one pair of partially miscible liquids, influence of temperature; systems with two pairs and three pairs of partially miscible liquids; the role of added salts.

NOTE: Numerical to be solved in possible units

REFERENCE BOOKS:

Mandatory:

1. Physical Chemistry, P. W. Atkins and Julio De Paula, 8th Edition, Oxford University Press
2. Quantum Chemistry, Ira N. Levine

Supplementary:

1. Physical Chemistry, J. M. Castellan.
2. Chemical Kinetics, K. J. Laidler, Tata McGraw Hill
3. Quantum Chemistry, R. K. Prasad, 3rd Edition, New Age International
4. Electrochemical Methods, A. J. Bond
5. Text Book of Physical Chemistry, Volume 1- 4; K. L. Kapoor; Macmillan India Limited

WEB REFERENCES:

1. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Kinetics/Modeling_Reaction_Kinetics/Transition_State_Theory/Eyring_equation
2. https://www.lenntech.com/library/ozone/decomposition/ozone-decomposition.htm
3. https://www.britannica.com/science/phase-rule
4. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Electrochemistry/Basics_of_Electrochemistry

Course Code: PGMP-CHE-DSC-403
Course Title: Fundamentals of Organic Chemistry
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

1. To develop the knowledge of students on the molecular orbital theory
2. To develop the knowledge of students on the concepts of topicity, pro stereoisomerism and chemo-, regio- and stereoselectivity in organic reactions
3. To develop the knowledge of students on mechanisms of reactions in organic synthesis

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Identify the presence of aromaticity, chirality and topicity in organic compounds
CLO2: State methods for determining reaction mechanisms
CLO3: Understand and apply HSAB concept
CLO4: Explain stereochemistry involved in various addition and elimination reactions

MODULE I: Stereochemistry **15 Hours**

Configurational nomenclature: *R* and *S*; D- and L- ; *E* and *Z*; *cis*and *trans*; *syn*and *anti* nomenclature; chirality in molecules with two and more chiral centres; conformational analysis of open chain compounds; *erythro*and *threo*nomenclature; structure, conformation and stereochemistry of monocyclic cycloalkanes (cyclopropane, cyclobutane, cyclopentane, cyclohexane, cycloheptane and cyclooctane) with simple substituents; topicity and prostereoisomerism- topicity of ligands and faces; homotopic, enantiotopic and

diastereotopicligands and faces; chemoselective, regioselective and stereoselective reactions; stereochemistry of *cis*- and *trans*-decalins; conformation and reactivity of cyclohexane, substituted cyclohexanes 'stereochemistry of cyclohexene and cyclohexanone' 2-alkyl and 3- alkyl ketone effect; introduction to stereochemistry of compounds containing N, S and P.

MODULE II: Molecular orbitals, delocalized chemical bonding, Structure and Reactivity 15 Hours

Molecular orbitals of simple acyclic and monocyclic systems, qualitative description; frontier orbitals; importance of FMOs in organic reactions; conjugation, cross conjugation, resonance, hyper conjugation and tautomerism; alternant and non-alternant hydrocarbons; aromaticity in benzenoid and non-benzenoid compounds; Huckel's rule; annulenes, aromatic, non-aromatic and anti-aromatic compounds; Acidity and basicity- different concepts, HSAB concept and factors affecting it; effect of structure and medium on acid and base strength; concept of super acids and super bases; electrophilicity and nucleophilicity, ambident nucleophiles and electrophiles, concepts and examples; tautomerism- concept, tautomeric equilibrium, relation with isomerism; types of tautomerism including ring, chain tautomerism and valence tautomerism; proto tropic shift in different systems.

MODULE III: Reaction Mechanism 15 Hours

Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes; types of- reactions, mechanisms; thermodynamic and kinetic- requirements, control; the Hammond postulate and principle of microscopic reversibility; methods for determining reaction mechanisms like identification of products; determination of the presence of intermediates (isolation, detection, trapping and addition of suspected intermediate); isotopic labeling; stereochemical evidence; kinetic evidence and isotope effect (sufficient reactions to exemplify each method be studied).

MODULE IV: Addition to carbon-carbon multiple bonds and elimination reactions 15 Hours Mechanism and stereochemistry of addition reactions involving electrophiles, nucleophiles and free radicals; addition of HCl, HBr, HI, HOH, R-OH, NH3, H2SO4, and halogen Br2 to carbon-carbon double and triple bonds in open chain and cyclic compounds; addition of H2 to C-C multiple bonds; hydroboration-oxidation and oxy mercuration/ demercuration; elimination reaction- the E2, E1 and E1cb mechanisms; orientation of the double bond, Saytzeff and Hofmann rule; effects of changes in the substrate, base, leaving group and medium on overall reactivity; comparison between E1, E2 and E1cb; elimination verses substitution; mechanism and orientation in pyrolyticsyn elimination; various examples involving cyclic and acyclic substrates.

REFERENCE BOOKS:

Mandatory:

1. Advanced Organic Chemistry Reaction, Mechanism and Structure, J. March, 4th Edition, John Wiley

Supplementary:

1. Stereochemistry and Chemistry of Natural Products, I. L. Finar; ELBS, Longmans
2. Stereochemistry, V. M. Potapov, MIR Publishers, Moscow
3. Organic Chemistry, F. A. Carey
4. Organic Chemistry, S.H. Pine; 5th Edition, McGraw-Hill International
5. Advanced Organic Chemistry, F. A. Carey, R. J. Sundberg; Vol I and II, Plenum Press
6. Fundamentals of Organic Reaction Mechanisms, M. Hamis, Carl C. Wamser, John Wiley and Sons
7. Organic Chemistry- A Concise Approach, F. M. Menger, D. J. Goldsmith and L. Mendell

8. Organic Laboratory Techniques; R. J. Fessenden, J. S. Fessenden, Brookes/Cole Publishing Company
9. Stereochemistry of Organic Compounds- Principles and Application, D. Nassipuri, 2nd Edition, Wiley Eastern Limited
10. Mechanism and Structure in Organic Chemistry, E. S. Gould et al.
11. Stereochemistry of Carbon Compounds, E. L. Eliel, Tata MacGraw Hill

WEB REFERENCES:

1. https://www.sciencedirect.com/topics/chemistry/stereochemistry
2. https://www.sciencedirect.com/topics/chemistry/detailed-reaction-mechanisms
3. http://web.chem.ucla.edu/~harding/notes/notes_14D_additionpibonds.pdf
4. http://www.chem.ucalgary.ca/courses/350/Carey5th/Ch05/ch5-4.html
5. http://home.iitk.ac.in/~madhavr/CHM102/Lec13.pdf

Course Code: PGMP-CHE-DSC-404
Course Title: Laboratory Course in Physical Chemistry
Credits: 2
Duration: 60 Hours
Maximum Marks: 50

Course Objectives:

1. To give students an overview of the different techniques and instruments used in physical chemistry laboratory

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Analyze and evaluate the experimental data and determine the energy of activation, entropy and free energy change involved in the given experiments
CLO2: Apply experimental techniques, such as conductometric measurements, titration, and viscosity measurements, to determine properties such as hydrolysis constants, molecular weight, critical temperature.

EXPERIMENTS:

1. To study the kinetics of hydrolysis of ethyl acetate and to determine: Energy of activation; Entropy of activation and Free energy change
2. To study the kinetics of the reaction between K2S2O8 and KI and to determine: Energy of activation; Entropy of activation and Free energy change.
3. To determine the order of reaction between potassium K2S2O8 and KI by graphical, fractional change and differential methods
4. To determine the degree of hydrolysis and hydrolysis constant of a salt obtained from weak base and strong acid using conductometer
5. To determine the composition of a mixture of acetic acid, monochloroacetic acid and hydrochloric acid by conductometric titration
6. To determine the equivalence point from derivative plot and determine the dissociation constants of a dibasic, malonic acid
7. To determine the dissociation constants from the derivative plot and the of a tribasic, phosphoric acid
8. To determine the formal redox potential from the derivative plot of Fe^{2+} / Fe^{3+} andCe^{3+} / Ce^{4+} system by potentiometric method
9. To study three component system of C6H5CH3; C2H5OH and H2O and obtain tie line
10. To study three component system of CH3COOH; CHCl3 and H2O and obtain tie line
11. To determine the molecular weight of high molecular weight polymer (Polystyrene)by viscosity

measurement
12. To determine CMC of soap by conductometric measurements
13. To determine the surface tension of liquid at different temperatures and hence the critical temperature of the liquid
14. To determine: i. the phase of naphthalene and diphenyl system ii. Freezing point diagram of *o*-nitro phenol and *p* - toluidine
15. To determine the composition of copper and iron (III) by photometric titration using disodium salt of EDTA

PRACTICAL BOOKS:

1. Practical Physical Chemistry, A. Finlay and J. A Kitchener; Longman
2. Experimental Physical Chemistry, F. Daniels, J. H. Mathews; Longman
3. Practical Physical Chemistry, A. M. James, J. A. Churchil
4. Experimental Physical Chemistry, D. P. Shoemaker, C. W. Garland; McGraw-Hill
5. Advanced Physical Chemistry, J. B. Yadav; Goel Publishing House, Meerut
6. Systematic Experimental Physical Chemistry, S. W. Rajbhoj, T. K. Chondhekar; Anjali Publication, Aurangabad

Course Code: PGMP-CHE-DSC-405
Course Title: Laboratory Course in Organic Chemistry
Credits: 2
Duration: 60 Hours
Maximum Marks: 50

Course Objectives:
1. To enable the students to apply certain theoretical concepts experimentally
2. To provide students with hands on experience on the basic laboratory techniques required for organic syntheses

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Gain the understanding of stoichiometric requirements during organic syntheses
CLO2: Understand safe and good laboratory practices, handling of laboratory glassware, chemical reagents and equipment
CLO3: Learn common laboratory techniques including reflux, distillation, steam distillation, vacuum distillation, and aqueous extraction
CLO4: To understand the synthesis of selected organic compounds

I. Laboratory Techniques
1. Introduction to safety techniques: First aid; Fire extinguishers; usage of hazardous chemicals
2. Simple distillation: Ethanol-water mixture using water condenser, Nitrobenzene and aniline using air condenser
3. Steam distillation: Clove oil from cloves or separation of *o*-and *p*- nitro phenols
4. Crystallization: Concept of induction of crystallization

i. Crystallization of phthalic acid from hot water using fluted filter paper and stem less funnel
ii. Acetanilide from boiling water
iii. Decolourisation and crystallization of brown sugar (sucrose) with activated charcoal using gravity filtration

5. Sublimation: Simple sublimation of camphor and succinic acid

II. Organic Synthesis
1. Aliphatic electrophilic substitution: Preparation of iodoform from ethanol and acetone
2. Aromatic electrophilic substitution: Preparation of p-bromoacetanilide

3. Oxidation: i. Benzoic acid from toluene ii. Iso-borneol to camphor using Jones reagent iii. Cyclohexanone from cyclohexanol (any one)
4. Reduction: p-nitrophenylmethylcarbinol from p-nitro acetophenone by NaBH4 and purification of the product through distillation under reduced pressure.
5. Bromination of an alcohol using KBr/ KBrO3 (at micro scale level)
6. Aldol condensation: Dibenzal acetone from Benzaldehyde
7. Cannizzaro reaction using 4-chlorobenzaldehyde as substrate
8. Preparation of benzylideneaniline from benzaldehyde
9. Preparation of chalcone from benzaldehyde and acetophenone
10. Esterification: Preparation of Butyl acetate from 1-Butanol

III. Extractions of:

11. Cinnamaldehyde from cinnamon sticks
12. Caffeine from tea bags

PRACTICAL BOOKS:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller; Prentice Hall
2. Organic Experiments, K. L. Williamson, D. C. Heath
3. Experimental Organic Chemistry, Vol I and II, P. R. Singh, D. S. Gupta, K. S. Bajpai; Tata McGraw Hill
4. Laboratory Manual in Organic Chemistry, R. K. Bansal; Wiley Eastern
5. Green Chemistry, Samuel Delvin; IVY Publishing House, Delhi
6. Organic Chemistry Laboratory, O. R. Rodig, C. E. Bell Jr. and A. K. Clark; Saunders College Publishing, New York
7. Organic Analytical Chemistry, Jag Mohan; Narosa Publishing House, New Delhi
8. Vogel's Textbook of Practical Organic Chemistry, A. R. Tatchell; John Wiley

Course Code: PGMP-CHE-DSE-401
Course Title: Reaction Mechanisms in Organic Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To enable students to understand electrophilic substitution reactions and mechanisms
2. To enable students to apply mechanistic concepts of nucleophilic addition to carbonyl group

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Understand organic reactions and be able to propose plausible mechanisms
CLO2: Choose appropriate reagents to carry out substitution reactions
CLO3: Understand the concepts of aromatic electrophilic and nucleophilic substitution reactions
CLO4: Utilize the knowledge of various name reactions to devise reaction pathways for various chemical transformations.

MODULE I: Aliphatic Nucleophilic and Electrophilic Substitution 15 Hours

The SN2, SN1, mixed SN1 and SN2 and SET mechanisms; neighbouring group mechanism, neighbouring participation by π and σ bonds, anchimeric assistance; classical and non-classical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements; the SNi mechanism; nucleophilic substitution at an allylic, aliphatic and vinylic carbon; reactivity effects of

substrate structure, attacking nucleophiles, leaving group and reaction medium; bimolecular mechanisms- SE2 and SEi; SE1 mechanism; electrophilic substitution accompanied by double bond shifts; effects of substrates; leaving group and the solvent polarity on the reactivity.

MODULE II: Aromatic electrophilic, nucleophilic substitution and addition to Carbon-Oxygen multiple bonds 15 Hours

Introduction to general mechanisms involved, reactivity of arenes, product distribution; ipso attack and orientation in benzene with more than one substituent; Friedel-Crafts and related reactions-alkylation, acylation, formylation; Vilsmeier reaction, Gattermann-Koch reaction; Fries rearrangement and Prins reaction; diazotization, nitrosation, nitration, sulphonation, mercuration; introduction to addition-elimination mechanisms and elimination-addition mechanism in aromatic nucleophilic substitution; Ullmann reaction; Schiemann reaction; Von Richter reaction; Sommelet-Hauser rearrangement; Smiles rearrangement; Mechanismof condensation reactions involving enolates- Aldol, Knoevenegel, Claisen, Darzen, Stobbe, Perkin and Benzoin reactions; hydrolysis of esters and amides; aminolysis of esters.

REFERENCE BOOKS:

Mandatory:

1. Advanced Organic Chemistry Reaction, Mechanism and Structure, J. March; 4th Edition, Wiley.

Supplementary:

1. Organic Chemistry, F. A. Carey
2. A Guidebook to Mechanisms in Organic Chemistry, P. Sykes; 6th Edition, Pearson Education.
3. Organic Chemistry, Clayden, Greeves, and Warren; Oxford University Press.
4. Mechanism and Structure in Organic Chemistry, E.S. Gould et al.
5. Organic Chemistry, S. H. Pine; 5th Edition, McGraw-Hill International.
6. Advanced Organic Chemistry, F. A. Carey, and R. J. Sundberg; Vol. I and II, Plenum Press.

WEB REFERENCES:

1. https://www.organic-chemistry.org/namedreactions/nucleophilic-substitution-sn1-sn2.shtm
2. https://www.sciencedirect.com/topics/chemistry/nucleophilic-aliphatic-substitution
3. http://www.chem.ucla.edu/~harding/notes/notes_14D_EAS01.pdf
4. https://www.sciencedirect.com/topics/chemistry/electrophilic-aromatic-substitution
5. https://www.masterorganicchemistry.com/2018/08/20/nucleophilic-aromatic-substitution-nas/

Course Code: PGMP-CHE-DSE-402
Course Title: Topics in Physical Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To enable students to study the physical behaviour and some chemical reactions under the influence of visible and ultraviolet light
2. To enable students to understand the concepts of magnetism
3. To enable students to understand the mechanism of the polymerization and its applications

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the thermodynamics and conformers of polymers and explore their diverse applications.

CLO2: Classify and differentiate between various types of magnetism.
CLO3: Analyze and interpret Jablonski diagrams, illustrating fluorescence and phosphorescence.
CLO4: Evaluate the principles and theories behind magnetic susceptibility.

MODULE I: Magneto chemistry **15 Hours**

Introduction; types of magnetism- diamagnetism, paramagnetism, ferromagnetism, anti-ferromagnetism and ferrimagnetism; electron spin and magnetic moment; theory of diamagnetism; Langevins theory; magnetic susceptibility and its measurements- Guoy's, Faraday's and Quinke's method; Ranking's transition metal complexes; ferromagnetism- domain theory; hysteresis in magnetism; ferrimagnetisms; magnetic anisotropy, magnetic exchange interactions; magnetic transition- Curie and Neel temperature; ceramic magnetic materials; applications of magnetic materials.

MODULE II: Photochemistry and Polymers **15 Hours**

Absorption and emission radiation of photochemical interest (Einstein's derivation equation, not expected); Frank-Condon principle; laws of photochemistry; Jablonski diagram illustrating fluorescence and phosphorescence; long range and short-range energy transfer; flash photolysis and lasers; photo reduction; photo oxidation; photosensitized reactions and photosynthesis; mechanism of chemiluminescence; Polymers- introduction, types; molecular weight distributions; mechanism of free radical; determination of chain length; condensation polymerization; degree of polymerization from kinetic data (derivation not expected); polymers- conformers, thermodynamics; conducting polymers and applications.

REFERENCE BOOKS:

Mandatory:

1. Polymer Science, V. R. Gowarikar, V. N. Viswanathan, JayadevSreedhar; New Age International Publishers
2. Fundamentals of Photochemistry, K. K. Rohatgi-Mukherjee; Wiley Eastern, New Delhi

Supplementary:

1. Magnetic susceptibility, L. N. Muley; Inter science Publishers, New York
2. Instrumental Methods of Chemical Analysis, B. K. Sharma; Goel Publishing House
3. Polymer Science and Technology, Joel R. Fried; Prentice- Hall of India Private Limited

WEB REFERENCES:

1. http://www.irm.umn.edu/hg2m/hg2m_b/hg2m_b.html
2. https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.britannica.com/science/polymer&ved=2ahUKEwitpqAx5HnAhVExTgGHQv8C24QFjAmegQIBxAB&usg=AOvVaw0-_N41elqjLur5vCql3p8z&cshid=1579501965101
3. http://www.ccl.net/cca/documents/dyoung/topics-orig/magnet.html
4. https://plastics.americanchemistry.com/plastics/The-Basics/
5. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/photchem.htm

Course Code: PGMP-CHE-DSE-403
Course Title: Diffraction Methods
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To give students an overview of diffraction methods in solid state chemistry for solving structural problem
2. To enable students to learn the use of excel in solving problems on X-ray diffraction

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the working of Spreadsheet based and Gaussian software in determining crystal structure.

CLO2: Interpret and analyze X-ray diffraction pattern.

CLO3: Evaluate the scope and limitations of single-crystal X-ray diffraction methods.

CLO4: Create comprehensive spreadsheets in Microsoft Excel to model and visualize crystal structures.

MODULE I: X-ray diffraction analysis **15 Hours**

Introduction, packing of spheres - cubic and hexagonal close packing; radius ratio rule, unit cell, types of unit cells and their characteristics; description of crystal structure; Bravias lattice; Bragg's Law, powder method, single-crystal X-ray diffraction; principle, instrumentation, scope and limitations of the method; X-ray scattering factors; calculations of unit cell dimensions from powder diffraction patterns for cubic, tetragonal and orthorhombic systems; reciprocal lattice concept; X-ray intensity calculations to decide the ionic configurations.

MODULE II: Problem solving through diffraction methods **15 Hours**

Introduction to spreadsheet-based software; Microsoft Excel; development of spreadsheets for some simple test cases like Gaussian curve (study the effect of standard deviation and centre of Gaussian), plotting of trigonometric functions like sin, cos and their linear combinations (Fourier synthesis for crystal structure determination); precise lattice parameter measurements; crystal structure determination- cubic; FCC, BCC, Hexagonal and other important crystal structure.

REFERENCE BOOKS:

Mandatory:

1. Solid State Chemistry and its Applications; A. R. West, John-Wiley and Sons,Chinchester

Supplementary:

1. X-ray diffraction: A practical Approach, C. Suryanarayana and M. Grant, Norton Plenum Press, New York
2. Elements of X- ray Diffraction, B. D. Cullity; Addison Wesley
3. Principles of Solid-State Chemistry, H. V. Keer; New Age International Ltd, New Delhi

WEB REFERENCES:

1. https://www.originlab.com/Origin
2. https://books.google.co.in/books?id=vk9fnLH56DYC&printsec=frontcover&dq=powder+diffraction+theory+and+practice&hl=en&sa=X&ved=0ahUKEwisvu--mpHnAhXPyDgGHW3XDMoQ6AEIZzAJ#v=onepage&q&f=false
3. https://link.springer.com/chapter/10.1007/978-1-4614-3954-7_12

https://epdf.pub/queue/powder-diffraction-theory-and-practice.html

SEMESTER II

Course Code: PGMP-CHE-DSC-406
Course Title: Spectroscopy in Chemistry
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:
1. To enable students to identify and characterize the samples
2. To enable students to identify the organic compounds using spectroscopic methods

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Understand the basic concepts of spectroscopic techniques
CLO2: Explain working mechanism involved for operating spectroscopic instruments
CLO3: Analyze representation of spectras for each spectroscopic technique
CLO4: Identify and characterize organic compounds using combined spectroscopic methods

MODULE I: General Introduction and Infrared Spectroscopy 15 Hours Interaction of electromagnetic radiation with matter and characterization; quantization of energy; regions of spectrum; atomic and molecular spectra; representation of spectra; electronic spectra, molecular structure; radiation sources; monochromators; signal-to-noise; resolving power; width and intensity of spectral transitions; Infrared spectroscopy- introduction, infrared absorption and molecular structure; near- Infrared spectrometry; molecular vibrations, factors influencing vibrational frequencies; instrumentation of FT-IR and sampling techniques; characteristic vibrational frequencies of various functional groups and frequency shifts associated with structural changes.

MODULE II: Atomic Absorption, Emission and Electronic Spectroscopy 15 Hours Atomic Absorption Spectroscopy- introduction, theory, instrumentation; Internal Standard and Standard Addition Calibration; applications; Flame Emission Spectrometry- introduction, theory, instrumentation; distribution between ground and excited states- atoms in the ground state; flame and electro thermal atomizers; ICP-AES theory, plasma sources, atomization and ionization, interferences in plasma and flame; Electronic spectroscopy- introduction, theory, chromophore and auxochrome; instrumentation; deviation from Beer-Lambert Law; Electronic spectroscopy- introduction; Woodward-Fischer rule; conjugated dienes, trienes, polyenes; α, ß- unsaturated carbonyl compounds; aromatic hydrocarbons; stereochemical factors.

MODULE III: NMR Spectroscopy 15 Hours
Introduction, theory, instrumentation; chemical shift, factors influencing chemical shift; solvents used in NMR; theory of spin-spin splitting and simple spin systems, AB, A2B2, A2B3; factors influencing coupling constant; introduction and principle to 13C; off resonance decoupled spectra.

MODULE IV: Mass Spectrometry, various techniques for structure determination 15 Hours
Basic principles; instrumentation; isotope abundances; molecular ion; metastable ions; fragmentation processes; fragmentation associated with simple components like alcohols, amines, alkenes, simple aromatic and aliphatic hydrocarbons, aldehydes, ketones, halogen compounds; structure elucidation using UV-VIS, IR, NMR, mass spectra.

REFERENCE BOOKS:
Mandatory:

1. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley

Supplementary:

1. Instrumental Methods of Chemical Analysis; G. W. Ewing, 5th Edition McGraw-Hill
2. Instrumental Methods of Chemical Analysis, H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle; 7th Edition CBS Publishing New Delhi
3. Analytical Chemistry: Principles, J. H. Kennedy, 2nd Edition; Saunders College Publishing
4. Spectroscopy of Organic Compounds, P. S. Kalsi; 2nd Edition; New Age International
5. Organic Chemistry, R. T. Morrison, R. N. Boyd; 4th Edition; Prentice Hall India
6. Organic Spectroscopy, William Kemp, Palgrave; 3rd Edition
7. Fundamentals of Molecular Spectroscopy, C. N. Banwell, E. M. McCash; 4th Edition Tata McGraw-Hill, New Delhi
8. Vogel's Textbook of Quantitative Inorganic Analysis, J. Mendham, R. C. Denney, J. D. Barnes and M. Thomas; 6th Edition, Pearson Education Asia
9. Spectrometric Identification of Organic Compounds, R. M. Silverstein, and F. X. Webster; 6th Edition, Wiley India
10. Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman; 4th Edition; Brooks/Cole

WEB REFERENCES:

1. http://www.chem.ucalgary.ca/courses/350/Carey5th/Ch13/ch13-ir-1.html
2. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/infrared-spectroscopy
3. https://www.sciencedirect.com/topics/materials-science/atomic-absorption- spectrometry

https://www.cis.rit.edu/htbooks/nmr/inside.html

Course Code: PGMP-CHE-DSC-407
Course Title: Fundamentals of Chemical Analysis
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

1. To enable students to understand the concept of titrimetry
2. To enable students to understand fundamental concepts in acid-base, precipitation, complex formation, redox system

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Determine equivalence point of various titrations theoretically
CLO2: Make basic quantitative calculations regarding a number of chemical concepts
CLO3: Understand and analyze the chemical reactions involved in different types of titrations
CLO4: Master the concepts like chemical equilibria, complexation, solubility, acidity and basicity and applications involved with respect to each type of titration methods.

MODULE I: Acid-Base Titrations and Conductometric Titrations 15 Hours

Acid-Base titrations- introduction, theory of acid-base indicators; range of indicator; selection of proper indicator; indicator errors; colour change; neutralization curves for strong acid-strong base, weak acid-strong base and weak base-strong acid weak acid-weak base titrations; poly functional acids and bases; titration curves for poly functional acids and bases; titration curves for amphiprotic species; determining the equivalence point; feasibility of acid- base titrations; magnitude of the equilibrium constant; effect of concentration; typical applications of acid-base titrations. Basic aspects of conductometric titration; types of conductometric titration; advantages and disadvantages of conductometric titration; Introduction; theory; instrumentation; advantages, disadvantages and applications of High frequency titrations.

MODULE II: Precipitation and Redox Titrations 15 Hours Precipitation titrations -introduction; feasibility; titration curves- effect of reaction completeness, effect of titrant and analyte concentration, for mixture of anions; indicators for precipitation titrations; the Volhard, the Mohr and the Fajans methods; typical applications of standard silver nitrate solution; Redox titration- introduction, equilibrium constants; electrode potentials in equilibrium systems; calculation of equilibrium constants; redox titration curves- formal redox potentials; derivatives of titration curves; factors affecting the shape of titration curves- concentration; completeness of reaction; titration of mixtures- feasibility of redox titrations; detection of end point and redox indicators; choice of indicator; structural aspect of redox indicators; specific and nonspecific indicators; sample preparation- pre-reduction and pre-oxidation; applications.

MODULE III: Complexometric Titrations 15 Hours
Introduction; complex formation reactions; stability of complexes; stepwise formation constants; inorganic complexing agents; titrations involving unidentate ligands; organic complexing agents; amino carboxylic acid titration; EDTA-acidic properties of EDTA, EDTA complexes with metal ions, equilibrium calculations involving EDTA in solution, EDTA titration curves; conditional formation constants; effect of other complexing agents on EDTA; factors affecting the titration curves; indicators for EDTA titrations; titration methods using EDTA- direct titration, back titration and displacement titration; indirect determinations; selectivity, masking and demasking agents; applications of EDTA titrations-hardness of water; magnesium and aluminium in antacids; magnesium and zinc in a mixture; analysis of ores and foods.

MODULE IV: Gravimetric Analysis 15 Hours
Introduction; properties of precipitates and precipitating reagents; conditions for precipitation; completeness of precipitates; super saturation and precipitate formation; particle size and filterability of precipitates; colloidal precipitates; crystalline precipitates; purity of the precipitate; co- precipitation, post precipitation; fractional precipitation; precipitation from homogenous solution; organic reagent as precipitant- dimethyl glyoxime; washing of precipitates; drying and ignition of precipitates; calculation from gravimetric data, applications of gravimetric method

REFERENCE BOOKS:

Mandatory:

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch; 8th Edition
2. Quantitative Analysis, R. A. Day, A. L. Underwood; Prentice-Hall

Supplementary:

1. Principles and Practice of Analytical Chemistry, F. W. Fifield, D. Kealy; Backwell Science Ltd., London
2. Vogel's Text Book of Quantitative Chemical Analysis; 6th Edition
3. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley, NY
4. Instrumental Methods of Chemical Analysis, H. Kaur; PragatiPrakashan
5. Quality in the Analytical Chemistry Laboratory, E. Prichard; John Wiley and Sons, NY

WEB REFERENCES:

1. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Book%3A_Analytical_Chemistry_2.1_(Harvey)/08%3A_Gravimetric_Methods/8.02%3A_Precipitation_Gravimetry
2. http://www.wiredchemist.com/chemistry/instructional/laboratory-tutorials/gravimetric-analysis/
3. https://chem.libretexts.org/Bookshelves/Ancillary_Materials/Demos%2C_Techniques%2C_a

nd_Experiments/General_Lab_Techniques/Titration/Acid-Base_Titrations
4. https://opentextbc.ca/chemistry/chapter/14-7-acid-base-titrations/
5. https://chem.libretexts.org/Courses/Northeastern_University/09%3A_Titrimetric_Methods/9.5%3A_Precipitation_Titrations
6. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Quantifying_Nature/Volumetric_Chemical_Analysis_(Shiundu)/14.4%3A_Complex_ion_Equilibria_and_Complexometric_Titrations

Course Code: PGMP-CHE-DSC-408
Course Title: Spectral Methods of Analysis
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:
1. To provide students with basics about the characterization of materials using XRD
2. To enable students to understand the concept of emission measurement for quantification of related compounds.
3. To provide students with basic knowledge about spectroscopy for identification of inorganic compounds.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Remember the basic concept involved in the spectroscopy techniques
CLO2: Understand and evaluate the strength and weaknesses of the different spectroscopy techniques
CLO3: Apply the knowledge of Mossbauer and electron spin spectroscopy in identification of compounds
CLO4: Analyze and interpret data of the various spectroscopic techniques.

MODULE I: X-ray Absorption, Diffraction; Neutron Diffraction, Fluorescence Spectroscopy 15 Hour s
X-ray absorption- introduction, theory, origin and interaction of X-ray with matter; X-ray spectrometer; Bragg's law; X-ray diffraction- introduction, theory; comparison of X-ray absorption and X-ray diffraction; X-ray diffraction by crystal; determination of crystal structure (single crystal and powder); interpretation of X-ray diffraction pattern; calculation of lattice parameters; neutron diffraction- introduction; theory; instrumentation and applications; X-ray fluorescence- introduction, applications; X-ray photoelectron spectroscopy.

MODULE II: Molecular Fluorescence, Phosphorescence and Chemiluminescence 15 Hours Fluorescence and phosphorescence- introduction, definition; principles of fluorescence, chemical structure and fluorescence; theory of molecular fluorescence; instrumentation- single and double beam filter fluorimeters; relationship between intensity of fluorescence and concentration; factors influencing fluorescence and phosphorescence; basic differences in measurement of fluorescence and phosphorescence; advantages; limitations and precautions; spectrofluorometer; phosphorimeter; selection of excitation wavelength for analysis; reporting fluorescence spectra; applications of fluorimetric analysis- inorganic, pharmaceutical, agricultural, biochemical and biomedical materials; Chemiluminescence- introduction, principle, types; meaning of luminescence, chemiluminescence; instrumentation; chemiluminescence titrations, chemiluminescence measurement; quantitative chemiluminescence; gas phase chemiluminescence analysis; electro- chemiluminescence.

MODULE III: Mossbauer Spectroscopy and Raman Spectroscopy 15 Hours Mossbauer Spectroscopy- introduction; principle; theory; instrumentation; line width;

isomer shift; quadrupole interaction; magnetic interaction; information on spin and oxidation states; structure and bonding; spin transition from spectra of different Mossbauer active nuclei in various environments; Mossbauer effect; application of Mossbauer effect to the investigations of compounds of iron and tin; Raman spectroscopy- introduction, light scattering by molecules, Raman effect- in solids, liquids, gases; mechanism; molecular structure; nature of Raman spectra; Raman activity of molecular vibrations; dynamic light scattering and determination of colloidal particle size.

MODULE IV: Microscopy and Electron Spin Resonance Spectroscopy 15 Hours

Chemical microscopy- microscope; parts and optical path; numerical aperture and significance; Kofler's hot stage microscope; fluorescence, polarizing; interference and phase microscopy; applications, qualitative and quantitative study; Electron microscopy- principle, operation, sample preparation, replicas, shadowing, application to analysis; electron probe analyzer, ion microscope; metallography- metallurgy, microscopic examination; specimen preparation and examination; interpretation of micrographs by SEM, EDAX, TEM, AFM; Electron Spin Resonance Spectroscopy- introduction; instrumentation, difference between ESR and NMR, Hyperfine interactions and qualitative analysis, study of free radicals, study of inorganic compounds, transition elements, structural determination.

REFERENCE BOOKS:

Mandatory:

1. Fundamentals of Molecular Spectroscopy, C. N. Banwell, E. M. McCash; 4th Edition Tata McGraw-Hill, New Delhi

Supplementary:

1. Elements of X- ray Diffraction; B. D. Cullity, Addison Wisley
2. Diffraction Method, Wormald, Oxford University Press
3. Neutron Scattering in Chemistry, E. ButleworthBaun, G, London
4. Mossbauer Spectroscopy, N. N. Greenwood, T. C. Gibbs, Chapmann Hall
5. Chemical Application of Mossbauer Spectroscopy, V. I. Goldanski and R. H. Harber, Academic Press
6. Spectroscopy in Inorganic Compounds, CNR Rao, G. R. Ferraro; Academic Press
7. Basic Principles of Spectroscopy, Cheney R. MacGrows Hill
8. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler; 5th Edition
9. Instrumental Methods of Analysis, B. K. Sharma, Goel Publishing House

WEB REFERENCES:

1. https://serc.carleton.edu/research_education/geochemsheets/techniques/XRD.html
2. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Map%3A_Principles_of_Instrumental_Analysis_(Skoog_et_al.)/15%3A_Molecular_Luminescence_Spectrometry
3. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/mossbauer-spectroscopy
4. https://serc.carleton.edu/research_education/geochemsheets/techniques/mossbauer.html
5. https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.nanoscience.com/techniques/atomic-force-microscopy/&ved=2ahUKEwjS-enSyJHnAhWXTX0KHWw1BqoQFjAaegQIAhAB&usg=AOvVaw2ou89f5fahKqUBqZgmLuIc&cshid=1579502355346

Course Code: PGMP-CHE-DSC-409
Course Title: Laboratory Course in Analytical Chemistry
Credits: 2
Duration: 60 Hours
Maximum Marks: 50
Course Objectives:

1. To provide students with an overview of the different analytical techniques for analysis

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Recall the various analytical instrumentation techniques.

CLO2: Understand the quantitative approach towards various instruments.

CLO3: Perform qualitative and quantitative analysis.

CLO4: Analyze and interpret the data.

I. UV-visible Spectrophotometer

1. To estimate the amount of D-glucose in given solution using Anthrone reagent
2. To determine the molar absorptivity of $KMnO_4$ and $K_2Cr_2O_7$ and simultaneously determine the amount of Manganese and Chromium in the solution
3. To estimate the amount of chloride by UV Visible spectrophotometer.

II. Flame Spectrophotometer

1. To estimate amount of Na/K from the given sample

III. Thermal Studies

1. TG-DTA studies on $CaC_2O_4.H_2O$ (Preparation of hydrate salt, Calculation of Iso thermal weight loss, Interpretation)
2. TG-DTA studies on $CuSO_4.5H_2O$
3. TG-DTA studies on Zn EDTA
4. DSC study on pharmaceutical product (Carbamazepine)

IV. Volumetric Method

1. To estimate the amount of Aluminium, Calcium and Magnesium from pharmaceutical sample.
2. Determination of Nickel by direct titration.

V. Ion Exchange Chromatography

1. To separate and estimate the amount of Ni and Co from the given mixture.
2. To separate and estimate the amount of chloride and bromide from the given mixture.

VI. Solvent Extraction

1. To extract copper as copper dithiocarbamate (DTC) from $CuSO_4$ using solvent extraction and estimate the amount of copper by spectrophotometric method.
2. To extract copper from $CuSO_4$ as neocuproin complex by solvent extraction and estimation by spectrophotometric method.

VII. Conductometric Titration

1. To study all types of strong and weak acid and base titrations by conductometric method using standard 0.1 N strong and weak acid and base solution.

PRACTICAL BOOKS:

1. Analytical Chemistry, G. D. Christian; 5th Edition, John Willey and Sons
2. Vogel's Textbook of Quantitative Inorganic Analysis, 6th Edition, Pearson Education, Asia
3. Collection of Interesting Chemistry Experiments, A. J. Elias, University Press
4. Quantitative Analysis, Day and Underwood; 6th Edition, Prentice Hall
5. Analytical Chemistry for Technicians, John Kenkel; 3rd Edition, Lewis Publishers.

Course Code: PGMP-CHE-DSC-410

Course Title: Laboratory Course in Inorganic Chemistry

Credits: 2

Duration: 60 Hours

Maximum Marks: 50

Course Objectives:

1. To enable students to prepare different coordination compounds and determine its purity

2. To enable students to analyse various inorganic analytes by various methods

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the chemistry of coordination compounds

CLO2: Apply volumetric methods to accurately estimate of various content involved in quantitative analysis techniques.

CLO3: Quantitatively analyze various metal ions from coordination compounds.

Preparation and Characterization of following Complexes

1. $K_3[Cr(SCN)_6].4H_2O$
2. $K_3[Cr(C_2O_4)_3]$ and estimate volumetrically the oxalate in the complex
3. Solid phase synthesis of trans-bisglycinato copper (II)
4. Potash alum from scrap aluminium (at micro scale level); to calculate the yield and percent purity
5. To prepare Mohr's salt and determine the number of water molecules of crystallization by titrating against potassium permanganate solution

Quantitative Estimations

1. Estimation of Nitrite by volumetric method
2. Estimation of Calcium from Calcite ore
3. Estimation of Copper in Gun Metal alloy iodometrically
4. Titrate the Zn (II) by $K_4[Fe(CN_6)]$ and verify the composition of the complex $K_3Zn_3[Fe(CN)_6]_2$
5. To estimate the amount of Cu/Fe/ Zn from the soil sample by AAS method
6. To determine the amount of copper from copper ammonia complex by Spectro photometric method.
7. To determine the amount of phosphate from water sample by heteropoly blue method.
8. To determine the amount of total chromium from water sample using 1, 5- diphenylcarbazide by spectrophotometry.
9. Spectrophotometric determination of chloride by methyl orange indicator

PRACTICAL BOOKS:

1. Vogel's Text Book of Quantitative Chemical Analysis; 3rd and 4th Edition
2. Handbook of preparative Inorganic Chemistry; G. Brauer, Volume: 1 and 2

Course Code: PGMP-CHE-DSE-404
Course Title: Topics in Inorganic Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To provide students with an overview of important topics in Inorganic Chemistry
2. To provide students with in-depth knowledge of various inorganic elements

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Recall and remember various allotropes of carbon, the intercalation compounds of graphite, carbon nanotubes, and zeolites.

CLO2: Understand the chemistry of: p-block elements, d-block elements, lanthanide and actinides

CLO3: Apply knowledge of Bronsted acidity and Lewis acidity to classify and predict the reactivity of acids and bases in different scenarios

CLO4: Analyze the chemical behavior of nitrogen, phosphorous, and sulphur compounds, exploring

the connections between their structures and reactivity

MODULE I: Main group elements and their selected compounds 15 Hours

Carbon group: allotropes of carbon, C60 and compounds (fullerenes), intercalation compounds of graphite, carbon nano tubes, carbides; compounds of silicon: silanes, silicates and silicones, Zeolites;

Nitrogen, phosphorous and sulphur compounds: Hydrides, oxides and oxy acids of nitrogen, phosphorous, sulphur and halogens. Phosphazines, phosphazene polymers, sulphur, nitrogen compounds: Binary sulphur nitrides: S_4N_4, S_2N_2 and $(SN)_x$., P-O and P – S cage compounds. Oxygen group, Chemistry of halogens and xenon: Interhalogens, psuedohalogens, polyhalide ions, oxyhalogen species. Xenon oxides and fluorides.

MODULE II: Chemistry of transition and inner transition elements 15 Hours

Transition elements: metallic character, oxidation states, atomic and ionic size, colour, melting points and boiling points, ionization energy, density, magnetic properties, catalytic properties, important compounds and complexes, biological importance, difference between first row and subsequent row elements.

Inner-transition elements: lanthanides and actinides- occurrence, properties, oxidation states, electronic structure, colour and spectra, magnetic properties, lanthanide contraction, compounds of lanthanides and actinides, separation techniques.

REFERENCE BOOKS:

Mandatory:

1. Inorganic Chemistry, D. F. Shriver and P. W. Atkins; 5th Edition, Oxford University Press

Supplementary:

1. Inorganic Chemistry: Principles of Structure and Reactivity, J. E. Huheey, E. A. Kiter; 4th Edition, Addison-Wesley Publishing House
2. Chemistry of the Elements, N. N. Greenwood and A. Earn shaw; Pergamon Press, Exetr, Great Britain
3. Advanced Inorganic Chemistry, F. A. Cotton, G. Wilkinson, Hurillo and Bochmann, 6th Edition, Wiley Inter science
4. Concise Inorganic Chemistry, J. D. Lee, 5th Edition, Chapman and Hall
5. Basic Inorganic Chemistry, F. A. Cotton and G. Wilkinson, Paul L. Gaus, 3rd Edition, John Wiley and Sons

WEB REFERENCES:

1. https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch11/acidbase.php
2. https://www.visionlearning.com/en/library/Chemistry/1/Acids-and-Bases/58
3. https://byjus.com/jee/lanthanides/
4. https://people.wou.edu/~courtna/ch462/tmcolors.htm
5. https://byjus.com/jee/f-block-elements

Course Code: PGMP-CHE-DSE-405
Course Title: Reagents in Organic Synthesis
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To provide students with knowledge of oxidation processes used in organic syntheses
2. To provide students with knowledge of reduction processes used in organic syntheses

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Study chemical reactivity of oxidizing and reducing agents

CLO2: Choose appropriate oxidizing agents for oxidation and reducing agent for reduction of a particular functional group

CLO3: Propose the mechanism of oxidation and reduction reactions

CLO4: Analyze different chemical transformations involving oxidizing and reducing reagents.

MODULE I: Oxidation reactions 15 Hours

Oppenauer oxidation, aromatization and dehydrogenation, oxidation of hydroxyl group with Triphenylbismuth carbonate, O2/Pt catalyst, silver carbonate/celite, sodium bromate/CAN and NaOCl/CH3COOH; chromium and manganese compounds: oxidation of alcohols, aldehydes, C-C double bonds and C-H bonds in hydrocarbons; peracids and other peroxides; types of peracids and preparation; oxidation of C-C double bonds in acyclic and cyclic systems, carbonyl compounds, amines and sulfides, allylic C-H bonds and oxidation with molecular oxygen; other methods of oxidation involving periodic acid, Na/K metaperiodate, lead tetra acetate, mercuric acetate, selenium dioxide, ruthenium tetroxide, osmium tetroxide, DMSO, thallium nitrate, DDQ, Prevost's reagent and Woodward conditions; ozonolysis, catalytic oxidation over Pt; photosensitized and palladium-catalyzed oxidation of alkenes.

MODULE II: Reduction reactions 15 Hours

Catalytic hydrogenation- different catalysts, solvents and equipment; functional group reductions and homogeneous catalytic hydrogenation; reductions by hydride-transfer reagents and related reactions- MPV reduction, NaBH4, NaB(CN)H3, Trialkylborohydrides, LAH and lithium hydridoalkoxyaluminates, mixed LAH-AlCl3 reagents, DIBALH and Reductions with borane and dialkylboranes; enzymatic reduction involving liver alcohol dehydrogenase/ NADH and Baker's yeast; other methods of reduction- Wolff-Kishner, Raney Ni desulphurisation, di-imide, low-valent titanium species, trialkyl tin hydrides andtrialkylsilanes; Green chemistry- principles; phase transfer catalysis; microwave synthesis; green reagents for oxidation, reduction processes; ultrasound synthesis; Electro-organic synthesis.

REFERENCE BOOKS:

Mandatory:

1. Some Modern Methods of Organic Synthesis, W. Carruthers; Cambridge University Press, Cambridge

Supplementary:

1. Modern Synthetic Reactions, Herbert O. House, W. A. Benjamin, 2nd Edition
2. Green Chemistry- Environment Friendly Alternatives, RashmiSanghi, M. M. Srivastava, Narosa Publishing House, New Delhi
3. Green Chemistry- Frontiers in Benign Chemical Synthesis and Processes, Paul T. Anastas and Tracy C. Williamson, Oxford University Press, Oxford
4. Advanced Organic Chemical Reaction, Mechanism and Structure, Jerry March, McGraw Hill International Books Company.
5. Advanced Organic Chemistry. F. A. Carey, R. J. Sundberg; Vol I and II, Plenum Press

WEB REFERENCES:

1. https://www.organic-chemistry.org/namedreactions/meerwein-ponndorf-verley-reduction.shtm
2. https://www.organic-chemistry.org/namedreactions/wolff-kishner-reduction.shtm

3. https://www.organic-chemistry.org/namedreactions/prevost-reaction.shtm
4. https://chem.pg.edu.pl/documents/614792/2c6c0579-c52b-400e-a396-07a03363f4e0

https://www.organic-chemistry.org/namedreactions/oppenauer-oxidation.shtm

Course Code: PGMP-CHE-DSE-406
Course Title: Bio analytical Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To enable students to the techniques routinely used in bio analytical laboratories
2. To enable students to study various bio analytical techniques used for diagnosis of diseases

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Understand various bio analytical techniques used for medical diagnosis and research.
CLO2: Analyze the principles and mechanisms behind different biosensors and its application.
CLO3: Evaluate the analytical applications of secondary antibody-antigen interactions and examining the keys to immunochemical measurements.
CLO4: Design and critically evaluate the principle and applications of immunoassays.

MODULE I: Antibodies, Spectroscopic Methods for Matrix Characterization 15 Hours

Antibodies- Introduction, structural, functional properties of antibodies, polyclonal and monoclonal antibodies; antibody- antigen interactions; analytical applications of secondary antibody-antigen interactions: agglutination reactions and precipitation reactions; keys to immunochemical measurements; analytical applications of biological tracers; principle and applications of radioimmunoassay (RIA); enzyme linked immune sorbent assay (ELISA); Introduction to the concept of RTPCR; immunohistochemistry- important diagnostic tool; introduction to protein; method for total protein- Lowry, Smith, Bradford; protein quantification methods; methods for total DNA- fluorometric, diphenylamine; total RNA; determination of total carbohydrate- ferricyanide, phenol sulphuric acid; Purpald assay for bacterial polysaccharides; free fatty acids.

MODULE II: Biosensors and Bio Analytical Approaches 15 Hours

Introduction to biosensors; examples of biosensor; configurations; response of enzyme-based biosensors; ferrocene-mediated amperometric glucose sensor; potentiometric biosensor for phenyl acetate; potentiometric immune sensor for digoxin; evanescent-wave fluorescence biosensor for bungaro toxin; optical biosensor for glucose based on fluorescence energy transfer; piezoelectric sensor for nucleic acid detection, enzyme thermistors; clinical genomics; proteomics and metabolomics; clinical diagnosis and screening; research and development; emerging pharmaceutical products, future perspectives; structure and characteristics of key transition metals, importance of transition metals in physiological processes, transition metals as mediators of disease processes, therapeutic implications of transition metals, determination of transition metals in nature

REFERENCE BOOK:

Mandatory:

1. Understanding Bio analytical Chemistry, V. A. Gault; John-Wiley and Sons

Supplementary:

1. Analytical Biochemistry, D. J. Holme; Pearson Education Ltd.

2. The principles of ion-selective electrodes and membrane transport, W. E. Morf
3. Bio analytical Chemistry, S. R. Mikkelsen; John-Wiley and Sons

WEB REFERENCES:

1. https://www.elprocus.com/what-is-a-biosensor-types-of-biosensors-and-applications/
2. Mehrotra, P. (2016, January 6). Biosensors and their applications – A review. Journal of Oral Biology and Craniofacial Research. doi:10.1016/j.jobcr.2015.12.002
3. https://www.radiologyinfo.org/en/info.cfm?pg=bodymr
4. https://www.iaea.org/topics/radiotracers
5. https://www.antibodies-online.com/resources/17/1215/radioimmunoassay-ria/

SEMESTER III

DISCIPLINE SPECIFIC ELECTIVES (DSE)

Course Code: PGMP-CHE-DSE-501
Course Title: Calibrations and Validation
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To enable students to understand the validation characteristics of some procedures used in laboratory
2. To enable students to have an idea about ICH guidelines used in pharmaceutical industry

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Understand the role of quantification, regulation and calibration in analytical methods.
CLO2: Apply the principles of method validation to various analytical equipment.
CLO3: Evaluate the robustness of various analytical techniques.
CLO4: Develop a calibration strategy for various instruments used in drug analysis.

MODULE I: Regulations and Qualifications 15 Hours

Regulations: Regulatory requirements for analytical method validation; validation of analytical methods; complete method validation package, analytical data, protocol, plan, revisions and change controls; International Conference on Harmonization (ICH) Guideline Q2A: Validation of analytical procedures; linearity and range criteria and their role in instrumental method validation; GMP (US), Qualification: Overview of qualification of instruments; installation, operation and performance qualification (IQ, OQ, PQ) of analytical equipments; method validation for UV Visible Spectrophotometer, IR Spectrophotometer, Spectrofluorometer, HPTLC, GC, HPLC; qualitative and quantitative method validation; parameters of validation; statistics in validation; detailed discussion on accuracy and precision role in method validation; protocols and interpretation.

MODULE II: Calibration 15 Hours

Calibration of analytical balance and pH meter; role of quantification limit and specificity; Limit of Detection (LOD) and Limit of Quantification (LOQ); Robustness and method validation;

Ruggedness of chromatographic method; Ruggedness of sample preparation procedure; Calibration verses Qualification verses Validation; Case study for HPLC, UV; calibration of various instruments used for drug analysis like HPTLC, UV-Visible Spectrophotometer, IR Spectrophotometer, Spectrofluorimeter, GC, HPLC.

REFERENCE BOOKS:

Supplementary:

1. The Theory and Practice of Industrial Pharmacy Lachman Edition
2. Web Resources in Pharmacy, In Pharma Publication, Bangalore
3. Schedule M
4. WHO Guideline
5. Analytical Method Development and Validation, Michael E. Swartz
6. Pharmaceutical Process Validation, Loftus and Nash
7. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R. C. Denny, J.D. Banes, Thomas; 6th Edition, ELBS
8. Pharmaceutical Process Validation, Alfred H. Wachter
9. Validation and Qualification in Analytical Laboratories, Ludwig Huber; 2nd Edition,
10. Wiley Publisher.

WEB REFERENCE:

1. https://uc.xyz/1mhmZR?pub=link
2. https://www.researchgate.net/publication/8508200_Qualification_of_analytical_instruments_for_use_in_the_pharmaceutical_industry_A_scientific_approach/link/02bfe50f872c59f953000000/download
3. https://www.slideshare.net/mobile/dhavalrock24/concept-of-ursdqiqoqpq
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4670047/
5. https://www.pharmaguideline.com/2010/05/calibration-of-uv-visible.html?m=1
6. https://nvlpubs.nist.gov

Course Code: PGMP-CHE-DSE-502
Course Title: Methods of Analysis
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To provide students with knowledge of thermal analysis to enable them to understand the principle of operation.
2. Obtaining basic knowledge on thermos-analytical methods
3. Application of thermos-analytical instruments in practice

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Define and recall the fundamental concepts of thermogravimetric Analysis and Differential Thermal Analysis

CLO2: Apply theoretical knowledge for practical analysis

CLO3: Analyze the experimental conditions for the measurements and combine different Thermos-analytical techniques.

CLO4: Proficiently solve numerical problems related to different gravimetric technique and evaluate the thermal and electrochemical properties of materials.

MODULE I: Thermogravimetric Analysis and Differential Thermal Analysis 15

Hours

Thermogravimetric Analysis- introduction; definition; instrumentation (all components to be discussed); interpretation of TGA curve; factors affecting TGA curves- instrumental, characteristics of sample; advantages and limitation of TGA; calculation of compound composition, percent decomposition; applications of thermogravimetry; Derivative Thermogravimetry (DTG)- definition, comparison between TG and DTG.

Differential Thermal Analysis- introduction, definition; theoretical basis of DTA; DTA instrumentation (all components to be discussed); factors affecting the DTA curve; advantages and disadvantages of DTA; applications of DTA.

MODULE II: Differential Scanning Calorimetry, Thermometric Titrations and Electrogravimetry

15 Hours

Differential Scanning Calorimetry- definition; instrumentation of DSC, types, factors affecting DSC curves; comparison between DTA and DSC techniques; applications. Thermometric Titrations- introduction; definition; instrumentation (all components to be discuss); Electro gravimetry- basic principles, completeness in deposition, composition of electrolyte, separation with controlled potentials, constant current electrolysis;

Numerical based on TGA and DTA curves to calculate percent loss and fix the formula of the sample are to be solved.

REFERENCE BOOKS:

Mandatory:

1.Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch; 8th Edition

Supplementary:

1. Principles and Practice of Analytical Chemistry, F. W. Fifield, D. Kealy; Backwell Science Ltd., London
2. Vogel's Textbook of Quantitative Chemical Analysis; 6th Edition
3. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley, NY
4. Instrumental Methods of Chemical Analysis, H. Kaur; PragatiPrakashan
5. Instrumental Methods of Chemical Analysis, Chatwal and Anand, Himalaya Publishing House

WEB REFERENCES:

1. http://web.abo.fi/instut/biofuelsGS2/kursen/%C5A/lectures/Lectrure_Thermal%20Analysis.pdf
2. https://www.pslc.ws/macrog/dsc.htm
3. https://www.brainkart.com/article/Thermometric-Titrations-(TT)_30858/

Course Code: PGMP-CHE-DSE-503
Course Title: Advanced NMR Spectroscopy
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To enable students to understand basic aspects of nuclear magnetic resonance spectroscopy
2. To enable students to understand one-dimensional NMR, Chemical shifts, J-coupling, Interpretation of 1D NMR spectrum, basics of 2D NMR, different 2D NMR experiments and their application/interpretation

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Define the basic principles of NMR spectroscopy.
CLO2: List the fundamental components and processes involved in NMR experiments.
CLO3: Interpret NMR spectra to extract information about chemical shifts, coupling constants, and peak integration.
CLO4: Evaluate the appropriateness of NMR spectroscopy as a tool for solving particular chemical problems.
CLO5: Innovate in the integration of NMR with other analytical techniques to solve interdisciplinary research problems.

MODULE I: ^{13}C-NMR, ^{19}F-NMR and ^{31}P-NMR Spectroscopy 20 Hours

Nuclear magnetic resonance- theory, quantum description; classical description of NMR; types of NMR spectra and its interpretation; applications of proton NMR in qualitative and quantitative analysis (in general); CW and PFT techniques; Types of CMR spectra-undecoupled- proton decoupled-off-resonance decoupled (SFORD)-selectivity decoupled and gated ^{13}CJ) and heteronuclear (^{13}C-^{1}H, ^{13}C-^{2}H) J couplings, nuclear overhauser effect, ATP (attached proton test), DEPT and Interpretation.

^{19}F and ^{31}P NMR Spectroscopy and Interpretation:Introduction, Fluorine coupling, coupling between Fluorine and Carbon, single fluorine and the CF_2group substituents- alkyl fluorides, carbonyl compounds, phosphorus compounds, multifluoroalkenes; Trifluoromethyl group. Origin of the ^{31}P NMR spectra, coupling with hydrogen, carbon, metals, transition metal complexes containing phosphorus.

MODULE II: 2D-NMR Spectroscopy 10 Hours

Classification and Interpretation of 2D experiments- 2DJ resolved spectroscopy- HOMO and HETERO- 2DJ Resolved Spectra: correlation spectroscopy (COSY) - HOMO-COSY, 2D-INADEQUATE and NOESY.

REFERENCE BOOKS:

Mandatory:

1. Spectroscopic Identification of Organic Compounds, R. M. Silverstein, G. C. Bassler and T. M. Morril
2. Introduction to Spectroscopy, Donald l. Pavia, Gary M. Lampman, George S. Kriz, James A.Vyvyan.

Supplementary:

1. Spectroscopic Identification of Organic Compounds, R. M. Silverstein and Webster
2. NMR in Chemistry- A Multinuclear Introduction, William Kemp
3. ^{13}C NMR for Organic Chemists, G. C. Levy, G. L. Nelson
4. Understanding NMR Spectroscopy, James Keeler; 2nd Edition
5. Guide to Fluorine NMR for Organic Chemists. By William R. Dolbier
6. Phosphorus-31 NMR Spectroscopy-A Concise Introduction for the Synthetic Organic and
7. Organometallic Chemist, OlahKühl, 2008 Springer-Verlag Berlin Heidelberg

WEB REFERENCES:

1. http://chem.ch.huji.ac.il/nmr/techniques/2d/2d.html
2. http://chem.ch.huji.ac.il/nmr/techniques/2d/noesy/noesy.html

Course code: PGMP-CHE-DSE-504
Course Title: Separation Techniques
Credits: 2

Duration: 30
Maximum Marks: 50

Course Objectives:

1. To give students a theoretical and practical introduction to the techniques of separation
2. To address modern challenges across the chemical, biological, and physical sciences as it is often necessary to isolate and examine chemical and biological species as pure substances

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Describe the chromatography methods of separation and its applications
CLO2: Acquire and understand technical knowledge and practical experience of different separation technique
CLO3: Evaluate the principles of inorganic molecular sieves, categorize different types of sieves, and assess their applications.
CLO4: Create approaches for solving analytical challenges using hyphenated techniques.

MODULE I: Advanced Chromatographic Techniques 15 Hours

Introduction to theory and principle of chromatographic technique; terms and parameters used in chromatography, band broadening and column efficiency; variables that affect column efficiency; Gas Chromatography- introduction, principle, theory, instrumentation; columns in GC; detectors- ionization, flame ionization, thermal conductivity, electron capture; evaluation of gas chromatogram; identification of chromatogram; comparison of GSC and GLC; applications; High Performance Liquid Chromatography- introduction; principle; instrumentation; pumps, column and column packing; column efficiency and selectivity; characteristics of liquid chromatography; types of detectors- UV, RI, and fluorescence detectors; advantages, comparison of HPLC and GLC; applications.

MODULE II: Miscellaneous Separation Techniques and Hyphenated Techniques 15 Hours

Gel chromatography- introduction, theory; principle of gel permeation chromatography- instrumentation and applications; theory and mechanism of ion exclusion; applications of ion exclusion technique; inorganic molecular sieves; principle; types of sieves; applications. Supercritical Fluid Chromatography-introduction; theory, principle; properties of supercritical-fluids; instrumentation and operating variables; comparison of SFC and other column methods, applications; Field-flow fractionation - theory, mechanism, types, and applications; Hyphenated Techniques- introduction; principle, instrumentation, applications of GC-FTIR; GC-MS; LC-MS, TG-MS.

REFERENCE BOOKS:

Mandatory:

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler; 9th Edition

Supplementary:

1. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley and Sons, NY
2. Khopkar, S. M. (1998). *Basic concepts of analytical chemistry*. New Age International.
3. Harvey, D. (2000). *Modern analytical chemistry*. McGraw Hill.
4. Chemical Instrumentation: A Systematic Approach, H. A. Strobel
5. Instrumental Methods of Chemical Analysis, H. Kaur; PragatiPrakashan
6. Vogel's Text Book of Quantitative Chemical Analysis; 6th Edition
7. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, J. A. Dean

8. Instrumental Methods of Chemical Analysis, B. K. Sharma; Goel Publishing House

WEB REFERENCES:

1. https://www.nottingham.ac.uk/-sczsteve/Ohlendieck%20and%20Harding%202018.pdf
2. http://www.chem1.com/acad/webtext/solut/solut-5.html
3. https://www.ijarnd.com/manuscripts/v2i4/V2I4-1168.pdf
4. Column Chromatography Made Simple: An Easy-to-Follow Guide (bitesizebio.com)
5. What is Column Chromatography? A Beginners guide (studyread.com)
6. Types of distillation columns | Headlands Distilling Co.
7. Raoult's Law and ideal mixtures of liquids (chemguide.co.uk)
8. https://www.pharmatutor.org/pharma-analysis/explain-electrophoresis-its-principle-and- factors-governing-it
9. https://www.iitk.ac.in/dordold/index.php?option=com_content&view=category&layout=blog&id=220&Itemid=239

Course Code: PGMP-CHE-DSE-505
Course Title: Quality Assurance and Quality Control in Analytical Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To enable students to understand the basics of quality control and quality assurance
2. To enable students to describe the types of packaging and regulatory aspects in food and pharmaceutical industries

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Understand the basic concepts of quality assurance, significance of specifications and tolerances in ensuring product quality
CLO2: Analyze the process of method verification and regulatory aspects in the context of food and pharmaceutical industries.
CLO3: Evaluate the impurity profile using prescriptive and performance-based approaches.
CLO4: Develop comprehensive approaches to solve quality-related issues in a laboratory setting

MODULE I: Introduction to Quality Assurance and Quality Control 15 Hours

Introduction to basic concepts, quality assurance; aspect of specification and tolerance; quality acceptance; sampling reality; cost aspect of quality decisions; quality control in raw materials; finished product; laws related to quality control; case studies of quality control in various industries like pharmaceuticals, agrochemicals, petrochemicals, dyes, plastics, polymers; safety in laboratory; importance of laboratory note book; cleaning and marking laboratory ware; measuring volume; calibrating volumetric flask; selecting and handling reagents and chemicals; methods of quality assessment- internal and external; evaluating quality assurance data- prescriptive approach and performance based approach.

MODULE II: Standard Method, Analysis; Packaging and Regulatory Aspects 15 Hours

Development of a standard method and analysis- introduction; optimizing experimental procedure (Standard Operating Procedures); verifying the method- single-operator characteristics; blind analysis of standard samples; ruggedness testing; validating standard method; two-sample collaborative testing and analysis of variance.
Packaging and Regulatory Aspects- introduction; types of packing material and regulations; acts in food and pharmaceutical industries; testing of material for packing; legal aspects in packing; regulatory aspects of foods, drugs and cosmetics; food safety and Standards Act, 2006; I.S.I., AGMARK, Government authorities concerned with testing, G.M.P. and C.G.L.P.S.; Department of WHO certification.

REFERENCE BOOKS:

Mandatory:

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch; 8th Edition

Supplementary:

1. Quality Assurance in Analytical Chemistry, W. Funk, V. Dammann, G. Donnevert; VCH Weinheim
2. Principles and Practice of Analytical Chemistry, F. W. Fifield, D. Kealy; Backwell Science Ltd. London
3. Vogel's Textbook of Quantitative Chemical Analysis; 6th Edition
4. Modern Analytical Chemistry, D. Harvey; McGraw-Hill Education
5. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley and Sons, NY
6. Instrumental Methods of Chemical Analysis, H. Kaur; PragatiPrakashan
7. Pharmacopeia of India, Volume I and II
8. Quality in the Analytical Chemistry Laboratory, E. Prichard; John Wiley
9. Principals of Package Development, Gribbinetal
10. Modern Packaging Encyclopaedia and Planning Guide- MacqraWreyco
11. Government of India Publications of Food Drug Cosmetic Acts and Rules

WEB REFERENCES:

1. https://asq.org/quality-resources/quality-assurance-vs-control
2. https://nvlpubs.nist.gov/nistpubs/Legacy/IR/nbsir85-3105.pdf
3. https://www.who.int/water_sanitation_health/resourcesquality/wqmchap9.pdf
4. https://www.who.int/medicines/areas/quality_safety/quality_assurance/control/en/
5. https://www.who.int/tdr/publications/documents/glp-handbook.pdf

Course Code: PGMP-CHE-DSE-506
Course Title: Chemometrics
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To provide students with a basic tool in solving problems

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Understand the different statistical approach and multivariate methods used in chemometric analysis
CLO2:Demonstrate a sound understanding of various multivariate methods and its application
CLO3:Analyse a comprehensive understanding of linear algebra to solve problems related to data

analysis
CLO4: Develop and execute factorial and half-factorial designs using Matlab

MODULE I: Introduction to Data and Statistics 15 Hours

Introduction; univariate statistics review; probability; variance and sampling, linear regression and calibration data, digitization, and the Nyquist Theorem, detection limit, S/N ratio, and signal filtering; review of linear algebra: scalars, vectors, and matrices, matrix notation and matrix operations orthogonality, analysis of variance (ANOVA)- 1 variable, analysis of variance- 2 variables; introduction to Matlab™: programmed, basics and layout, matrix operations in Matlab™ the diary command and examples, ANOVA in Matlab™ experimental design: factorial design, simple versus complex models, factorial design in Matlab™; half-factorial design.

MODULE II: Multivariate Methods 15 Hours

Introduction to various multivariate methods; the six habits of a chemometrician; principle component analysis (PCA); data pretreatment- mean centering and normalization; PCA in Matlab™.

Classical least squares (CLS), CLS in Matlab™, inverse least squares (ILS).

Multiple linear regression (MLR); principle component regression (PCR); partial least squares, examples in Matlab™; summary of multivariate methods; pattern recognition- supervised versus unsupervised pattern recognition, K nearest neighbours (KNN); soft independent modelling for chemical analysis (SIMCA), summary of pattern recognition.

REFERENCE BOOK:

Mandatory:

1. Chemometrics, A Practical Guide; Kenneth R. Beebe, Randy J. Pell, and Mary Beth Seasholtz, John Wiley and Sons, Inc., New York

Supplementary:

1. The computer program MATLAB™ will be required for some portions of the course

WEB REFERENCES

1. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Chemometrics_Using_R_(Harvey)/00%3A_Front_Matter/What_is_Chemometrics_and_Why_Study_it%3F
2. https://www.frontiersin.org/articles/10.3389/fchem.2018.00576/full
3. https://www.mn.uio.no/astro/english/services/it/help/mathematics/matlab/matlab_prog.pdf

DISCIPLINE SPECIFIC RESEARCH ELECTIVES (DSRE)

Course Code: PGMP-CHE-DSRE-501
Course Title: Research Methodology and Academic writing
Credit: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

The Course will enable the students to

1. Understand the fundamental concepts and components of research methodology, including research types, approaches, and the significance of research.

2. Apply knowledge to design sample surveys, considering sampling errors, measurement scales, data collection methods and the development of measurement tools.
3. Recognize the components of an academic paragraph and their role in conveying ideas effectively.
4. Recall the importance of referencing and citing sources in academic writing.
5. Understand the concept of plagiarism and its ethical implications.
6. Synthesize information from various sources to construct a well-structured academic paper.

Course Learning Outcomes:

Upon successful completion of this course students will

CLO1: Study the research objectives, types, and approaches through the analysis of research significance and the application of criteria for quality research.

CLO2: Compare and choose between various research writing styles, tools for measurement with respect to specific contexts.

CLO3: Write a compelling theory for a given research challenge in accordance with research ethics

CLO4: Evaluate and critique academic writing to ensure adherence to established rules and standards.

CLO5: Assess the credibility of sources, including journals and digital content, for research purposes

CLO6: Design a research paper using proper referencing and citation techniques:

MODULE I: Understanding Research 15 Hours

Research methodology – introduction, objectives, types of research, research approaches, significance of research, research process, criteria of a good research

Defining a research problem- selecting the problem, necessity of defining the problem, technique involved in defining the problem

Research design – meaning, need of research design, features of a good design, concepts related to research design, types

Design sample surveys- Introduction, sample design, sampling and non- sampling errors, types of sampling designs.

MODULE II: Tools and Techniques of Research Writing 15 Hours

Measurement and scaling, quantitative and qualitative data, classification of measurement scales, goodness of measurement scales, sources of errors in measurement, techniques of developing measurement tools, scaling – classification and techniques

Data collection – introduction, experiments in surveys, collection of primary and secondary data, selection of appropriate methods for data collection, case study method

Data preparation process – questionnaire checking, editing, coding, classification, tabulation, graphical representation, data cleaning, data adjusting, problems in preparation process, types of analysis

Interpretation and report writing- techniques, different steps in writing report, layout of research report, types of report, oral presentation, precautions for writing research reports

MODULE III: Introduction to Scientific Writing and Literature Review 15 Hours

Importance and Rules of Academic Writing, styles of research writing, paragraph structure, Quotation plagiarism, sources- journals, digital content; Author metrics, style of research writing, impact factors, types of index, challenged in research Process and Source of Literature- journal, digital, web, periodicals; referencing, citations, the writing process.

MODULE IV: Thesis and Model Writing **15 Hours**

Inclusions - cover and title pages, abstract, introduction, table and figure formats, text, objectives, methodology, analysis, summary, conclusion, bibliography; plagiarism, Layouts – fonts, spacing, visual effects, labelling, visual presentation of data, creating images using apps, and related aspects, paraphrasing; Writing model-formal letter, CVs, designing in report surveys, and comparison essay.

REFERENCE BOOKS:

Mandatory:

1. Kotahri, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Ed.Reprint, New Age International Publishers
2. Singh YK. 2006. Fundamentals of Research Methodology and Statistics. New Age International Publishers.

Supplementary:

1. Krishnan V. 2011. Statistics for Beginners. Atlantic Publishers and Distributors (P) Ltd.
2. Jackson SL. 2012. Research Methods and Statistics: A Critical Thinking Approach. Fourth Edition. Wadsworth Cengage Learning.
3. Mathukutty M Monippally, Academic Writing: A Guide for Management Students and Researchers, ISBN 9788132104414, Sage Publications, New Delhi, India.
4. Bell, J., & Waters, S. (2018). *Ebook: doing your research project: a guide for first-time researchers*. McGraw-hill education (UK).
5. Kumar, R. (2018). Research methodology: A step-by-step guide for beginners. *Research methodology*, 1-528.
6. Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: an introduction (8. utg.). *AE Burvikovs, Red.) USA: Pearson*

WEB REFERENCES:

1. https://egyankosh.ac.in/handle/123456789/35677
2. https://docstate.academy/courses/qualitative-analysis-and-review-writing/
3. https://shop.elsevier.com/books/writing-research/clare/978-0-443-07182-9
4. https://www.scribbr.com/dissertation/methodology/#:~:text=It%20involves%20studying%20the%20methods,surveys%2C%20and%20statistical%20tests).
5. https://www.indeed.com/career-advice/career-development/research-methodology
6. https://gradcoach.com/what-is-research-methodology/
7. https://ccsuniversity.ac.in/bridge-library/pdf/Research-Methodology-CR-Kothari.pdf
8. https://research.com/research/how-to-write-research-methodology
9. https://euacademic.org/BookUpload/9.pdf
10. https://www.slideshare.net/RonitRKharade/research-tools-and-techniques-245926961

Course Code: PGMP-CHE-DSRE-502
Course Title: Experiments in Analytical Chemistry
Credits: 4
Duration: 120 Hours
Maximum Marks: 100

Course Objectives:

1. To enable students in understanding the knowledge of separation and characterization
2. To enable students to carry out, record and analyze the result of analytical experiments

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the quantitative approach towards various instruments
CLO2: Identify appropriate method to carry out quantitative analysis for desired samples
CLO3: Perform titrimetric and spectrophotometric analysis
CLO4: Evaluate statistical spectrophotometric data and interpret the absorption spectra's

MODULE I: Analysis of Pharmaceutical Tablets / Samples

1. Estimation of calcium from dietary supplements using Murexide indicator
2. Estimation of Ibuprofen / Paracetamol
3. Estimation of sulphadiazine / sulphonamide
4. Determination of neutralizing power of tablets of different brands and compare effectiveness
5. Determination of iron using Zimmermann-Reinhardt reagent by titrating against potassium permanganate
6. Estimation of iron from given pharmaceutical drug sample using thioglycolic acid

MODULE II: Ion Exchange Chromatography and Solvent Extraction Method

1. To determine the capacity of a cation exchange resin
2. To determine the capacity of an anion exchange resin
3. To determine the Fe ion as Fe-oxine complex using Butyl acetate/ $CHCl_3$ as extracting solvent.
4. To separate the acidic, basic and neutral compounds from the mixture by solvent extraction.

MODULE III: Electrochemical Method

1. pH-metric determination of hydrolysis constant of aniline hydrochloride
2. pH-metric determination of the acid-base dissociation constant and isoelectric point of amino acid
3. pH metric determination of dissociation constant of dibasic, oxalic acid
4. Potentiometric estimation of carbonate and bicarbonate from the mixture
5. Potentiometric determination of dissociation constant for Cu-ammonia complex
6. To determine the critical micelle concentration of the detergent using conductometer.

MODULE IV: Simple Chromatography

1. To separate alpha amino acids by paper chromatography
2. To separate the two organic compounds from the mixture by TLC
3. To separate the leaf pigments: chlorophyll 'a'chlorophyll 'b', carotene and xanthophylls by paper chromatography
4. To determine the R_f value of glycine by ascending paper chromatography
5. To separate sugars and amino acids by paper and thin layer chromatography
6. To separate the mixture of o- and p- nitro anilines by column chromatography
7. To study the presence of lactose in milk by descending paper chromatography

MODULE V: Spectrophotometric Method

1. To determine pka value of methyl red indicator at room temperature
2. To determine the indicator constant and isobestic point of an indicator
3. To determine the stoichiometry and stability constant of ferric salicylic acid complex by Job`s method and mole ratio method
4. To determine the amount of each p-nitrophenol and m-nitrophenol from the mixtureby spectrophotometric titration using standard NaOH solution at λ max= 280 nm
5. To record the UV absorption spectrum of acetone in n-hexane and identify the various transitions
6. To estimate the amount of aspirin and caffeine from APC tablet by UV-Visible spectrophotometry
7. To study the iodination of acetone by spectrophotometric method
8. To estimate the amount of arsenic in dried shrimp by UV-Visible spectrophotometry using

molybdenum blue method.

MODULE VI: Interpretation Exercise

1. X-ray powder diffraction analysis of cubic compound:
a. Determination of Lattice constants and crystallite Size
b. Density
2. Interpretation of Mossbauer spectrum with reference to determination of: isomer shift; quadruple splitting; internal magnetic field; general comment
3. Interpretation of IR spectrum with reference to stretching vibration of: C=N; C=O; N-O; M-O
4. Interpretation of NMR spectrum with reference to calculation of chemical shifts and general comments
5. Interpretation of absorption spectra for:
a. Verification of the position of ligands in spectrochemical series
b. Calculation of spectral splitting parameters
c. Determination of geometry of a given compound (octahedral, tetrahedral, square planar)
6. Statistical revaluation of spectrophotometric data

PRACTICAL BOOKS:

Supplementary:

1. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition
2. Comprehensive Experimental Chemistry, V. K. Ahluwalia; New Age Publications
3. Experimental Physical Chemistry, F. Daniels and J. Williams
4. Experimental Physical Chemistry, R. C. Das and B. Behera
5. Practical Physical Chemistry, B. Viswanathan, P. S. Raghavan
6. An Introduction to Practical Biochemistry, D. T. Plummer; 3rd Edition, Tata McGraw-Hill, New Delhi
7. Advanced Physical Chemistry, J. B. Yadav; 14th Edition, Goel Publishing House
8. Systematic Experimental Physical Chemistry, S. W. Rajbhoj, T. K. Chondhekar; Anjali Publication, Aurangabad.

VIDEO REFERENCES:

1. https://www.youtube.com/watch?v=lha8dEBNFS4&t=251s

Course Code: PGMP-CHE-DSRE-503
Course Title: Experiments on analytical instrumentation
Credits: 4
Duration: 120 Hours
Maximum Marks: 100

Course Objectives:

1. Familiarize students with principles, components, and operation of spectroscopy, potentiometry, chromatography and thermal methods of analysis.
2. Teach students to prepare and handle samples for analysis, including proper techniques for sample collection, extraction and pre-treatment.
3. Give students opportunities for hands on experience with the instruments, ensuring proficiency in their use.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Demonstrate proficiency in operating and maintaining analytical instruments
CLO2: Analyze various types of chemical sample using proper techniques
CLO3: Plan experiments and draw conclusions from data

CLO4: Interpret data obtained from instruments and use appropriate software for data processing and presentation

MODULE I: IR Spectroscopy

1. Quantification of acetyl group from polymers using IR
2. Plasticizer from PVC using IR
3. Determination of ethanol in gasoline
4. Spectral analysis of different compounds (synthesized inorganic complexes and organic compounds)
5. Microscale analysis of patterning reactions via FTIR imaging

MODULE II: Potentiometry

1. Potentiometric determination of reducing sugars
2. Potentiometric titration using graphite sensor
3. Kinetics of bromination reaction: A potentiometric study
4. Non-aqueous titration containing mixture of aniline and ethanolamine

MODULE III: Gas Chromatography

1. To develop and validate the analytical method of any one drug using GC
2. Synthesis of high boiling organic compound by derivatization and analyses by GC
3. Separation of alcoholic mixtures
4. Determination of alcoholic content in: i. Beer ii. Wine iii. Local drinks
5. Gas chromatographic analysis for: i. automobile exhaust ii. Cigarette smoke
6. Analysis of preservatives from solid and liquid samples (extraction, sample preparation and analysis)
7. Internal normalization for the quantitative analysis of solvents using GC.
8. Determination of trace amounts of metals as their chelate complexes using GC.
9. Gas chromatographic analysis for a mixture of gases like O_2, N_2 and CO_2

MODULE IV: High Performance Liquid Chromatography

1. Determination of caffeine content in: i. Tea ii. Coffee iii. Soft drinks iv. Chocolates
2. Purity of the solvents using HPLC
3. Optimum flow rate for the determination of chloroform using Van Deemter equation
4. Quantitative analysis of a mixture of chloroform and carbon tetrachloride
5. Analysis of mixture of alcohols using HPLC
6. To study the quantitative assay of ampicillin injection powder by using HPLC
7. To analyze the mixture of two hydrocarbons (Toluene and Nitrobenzene) by HPLC
8. Analysis of Ibuprofen/Paracetamol (analgesics) in a commercial sample/tablet by HPLC
9. To develop and validate the analytical method of any one drug using HPLC
10. To determine the number of theoretical plates by HPLC using acetophenone as reference material
11. Quantitative analysis of aspirin, phenacetin and caffeine in a mixture by using HPLC.

MODULE V: TG/DTA/DSC

1. Determination of the purity of pharmaceuticals samples
2. Thermal decomposition of calcium oxalate monohydrate
3. Thermal decomposition of copper sulphatepentahydrate
4. Thermal decomposition of nickel oxalate dihydrate
5. Determination of calcium and magnesium in dolomite
6. Glass transition temperature of polymers (polymer to be used in preparation of membrane sensor)
7. Determination of water of crystallization in coordination compounds/ inorganic salts Studies on

thermal decomposition of Zinc NTA salt
8. DSC study on pharmaceutical product
9. Determination of calcium sulphatedihydrate in cement
10. Determining the purity of pharmaceutical drug: Phenacitin

MODULE VI: Atomic Absorption Spectroscopy
1. Analysis of Na, K and Ca in water samples
2. Analysis of metal ion from soil /ore
3. Analysis of metal ion from alloys: Fe and Cr from steel
4. Analysis of total metals in soil sample: Zn and Cu
5. Determination of metals in food products
6. Determination of K in fertilizers
7. Analysis of Lead and cadmium in toys

PRACTICAL BOOKS:

Supplementary:

1. Vogel, A. I., & Jeffery, G. H. (1989). Vogel's textbook of quantitative chemical analysis.
2. Kealey, D. (2013). Experiments in modern analytical chemistry. Springer.
3. Meloan, C. E. (1999). Chemical separations: Principles, techniques, and experiments (p. 155). Wiley.
4. Comprehensive Experimental Chemistry, V. K. Ahluwalia; New Age Publications

WEB REFERENCES:
1. Department of Polymer Science at the University of Southern Mississippi Web Site, the Macrogalleria; http://www.psrc.usm.edu/macrog/pvc.htm
2. Microscale analysis of patterning reactions via FTIR imaging: Application to intelligent hydrogel systems – ScienceDirect
3. Lab 14 (terrificscience.org)
4. 4.6 Determination of sodium, potassium, magnesium, and calcium in precipitation (nilu.no)

GENERIC ELECTIVES (GE)

Course code: PGMP-CHE-GE-501
Course Title: Food Chemistry and Nutrition
Credits: 2
Maximum marks: 50
Duration: 30 Hours

Course Objectives:

The Course will enable the students to
1. Recall the essential macronutrients and micronutrients required for human nutrition.
2. Identify the classification of carbohydrates, proteins, fats, vitamins, minerals, and water in the diet.
3. Explain the functions and roles of carbohydrates in the human body, including dietary fiber.
4. Describe the different types of lipids and their significance in nutrition.
5. Analyze the nutritional significance of macro and micro nutrients in maintaining overall health.
6. Infer the effects of natural colors and flavouring agents on consumer choices and food safety.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Identify the major classifications of dietary fibers, lipids, water-soluble and fat-soluble vitamins, major minerals, and trace minerals.

CLO2: Explain the functions of macro and micro nutrients in the human body, specifically in digestion, absorption, and overall health.
CLO3: Apply knowledge of intentional additives, incidental additives, natural colors, flavoring agents, and their roles in food products.
CLO4: Analyze the hazards in the food supply chain and identify potential sources of contamination.

MODULE I: Macro and Micro Nutrients 15 hours

Introduction to macro and micro nutrients- Carbohydrates - Introduction, classification and dietary fibers; Proteins introduction, classification; Fats- Introduction and types of lipids; Vitamins- water soluble and fat-soluble vitamins; Minerals - Major minerals and trace minerals and their functions; Water and its functions. Role in human body-digestion and absorption.Nutritional significance and changing trends in dietary intake.Recommended dietary allowances.

MODULE II: Additives and Contaminants 15 hours

Intentional additives, Incidental additives or contaminants, Natural colors and flavouring agents, Toxic trace elements, Metal uptake in canned foods, Plant protective agents- Pesticides; monitoring pesticides in food, Veterinary drugs, Persistent environmental chemicals, Naturally occurring toxicants; control and measures, Hazard identification in the food supply chain, Organic and inorganic contaminants in food- metals and metalloids, nitrates, hydrocarbons, Chemical migration from food packaging.

REFERENCE BOOKS:

Mandatory:

1. Srilakshmi, B. (2006). *Nutrition Science*. New Age International.
2. Principles of food chemistry third edition by John M.deMan, Phd
3. Basic food chemistry, 2nd edition, Frank A. Lee, PhD

Supplementary:

1. Annual Reviews of Nutrition. Annual Review Inc, California, USA.
2. Shils, M.E.; Olson, J.; Shike, M. and Roos, C. (1998): Modern Nutrition in Health and Disease, 9th edition. Williams and Williams. A Beverly Co. London.
3. Bodwell, C.E. and Erdman, J.W. (1988) Nutrient Interactions. Marcel Dekker Inc. New York
4. World Reviews of Nutrition and Dietetics.
5. WHO Technical Report Series.
6. Indian Council of Medical Research. Recommended Dietary Intakes for Indians - Latest Recommendations.
7. Indian Council of Medical Research. Nutritive Value of Indian Foods - Latest Publication.
8. Berdanier, C.D. and Haargrove, J.L. (ed) (1996): Nutrients and Gene Expression: Clinical Aspects. Boca Raton, FL CRC Press.
9. Baeurle, P.A. (ed) (1994) Inducible Gene Expression. Part I: Environmental Stresses and Nutrients. Boston: Birkhauser.
10. Chandra, R.K. (ed) (1992): Nutrition and Immunology. ARTS Biomedical. St. John's Newfoundland.
0. International Life Sciences Institute Present Knowledge in Nutrition – latest edition

JOURNALS:

1. Nutrition Reviews
2. Journal of Nutrition
3. American Journal of Clinical Nutrition

4. British Journal of Nutrition
5. European Journal of Clinical Nutrition
6. International Journal of Vitamin and Nutrition Research
7. International Journal of Food Science and Nutrition
8. Nutrition Research
9. Annals of Nutrition and Metaboli

Course Code: PGMP-CHE-GE-502
Course Title: Environmental Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:
The Course will enable the students to
1. Identify and define various types of pollution, such as air, water, soil, noise, radioactive and microplastic pollution.
2. Recall key pollutants associated with each type of pollution.
3. Explain the causes and sources of different types of pollution.
4. Interpret the environmental and health impacts of pollution on ecosystems and human populations.
5. Evaluate the effectiveness of pollution control measures in various industries and sectors.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Study the monitoring of air pollution, Water Pollution, Soil Pollution, Noise Pollution, Radioactive pollution and occurrence of Microplastics.
CLO2: Explain the causes and sources of different types of pollution. including air, water, soil, noise pollution etc
CLO3: Identify methods to control the various types of pollution.
CLO4: Summarize the impact of pollution on ecosystems, human health, the environment and techniques for the waste disposal.

MODULE I: Air Pollution, Water Pollution and Soil Pollution 15 Hours
Air pollution- natural and anthropogenic sources of pollution, primary and secondary pollutants, transport and diffusion of pollutants, Methods of monitoring and control of air pollution, SO_2, NOx, CO, SPM.
Water pollution – Introduction to water pollution; sources and consequences, types of pollutants in ground water, Geological and anthropogenic pollutants in ground water - movements of contaminants in ground water; Heavy metals in aquatic systems - cycling, interactions and transport - factors affecting, sewage and wastewater treatment and recycling; advanced waste water treatment.
Soil pollution: Types, sources and consequences, Transport processes — biological process-microbial transformation of heavy metals, industrial waste effluents and heavy metals and their interactions with soil components, analysis of soil quality, soil pollution control.

MODULE II: Noise Pollution, Radioactive Pollution and Microplastics 15 Hours
Noise pollution - sources of noise pollution, measurement and indices, Marine pollution, sources of marine pollution and its control, Effects of pollutants on human beings, plants, animals and climate, air quality standards and air pollution

Radioactive Pollution- Radioactivity in the environment, Radionuclides- sources, types of radiation, Radioactive fallout, Ecological risks from radiation, effects on humans, exposure standards. nuclear power plants and fuel production; waste generation from nuclear power plants; radioactive waste treatment, disposal options.
Microplastic: occurrence, fate and waste management, The Microplastic Cycle: An Introduction, Microplastics in Terrestrial and Freshwater Environments, Marine Microplastics, Exposure, The interactions ofmicroplastics and chemical pollutants, Analysis and Techniques for Collection, Removal and Degradation.

REFERENCE BOOK:

Mandatory:

1. De Anil, K. (2003). *Environmental chemistry*. New Age International.

Supplementary:

1. Murali Krishna, K. V. S. G. (1995). Air pollution and control. Kaushal& Co., Kakinda AP, 215215.Manahan, S. E. (2022). Environmental chemistry. CRC press.
2. Bell, L. H., & Bell, D. H. (2017). Industrial noise control: Fundamentals and applications. CRC Press.
3. Bank, M. S. (2022). Microplastic in the environment: pattern and process (p. 354). Springer Nature.
4. Masters, G. M. (1998). Introduction to environmental engineering and science.
5. Andrady, A. L. (2011). Microplastics in the marine environment. Marine pollution bulletin, 62(8), 1596-1605.
6. Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: a review. Marine pollution bulletin, 62(12), 2588-2597

REFERENCE LINK:

1. Water pollution | Definition, Causes, Effects, Solutions, Examples, & Facts | Britannica
2. Causes, Effects and Solutions of Groundwater Pollution - Conserve Energy Future (conserve-energy-future.com)
3. Soil Pollution: Definition, Causes, Effects and Solutions - Conserve Energy Future (conserve-energy-future.com)
4. Soil - Detoxification, Pathways, Microorganisms | Britannic

Course code: PGMP-CHE-GE-503
Course Title: Application of Chemistry in Everyday Life
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objective:

The course will enable the students to

1. Identify common chemical compounds found in everyday products.
2. Impart knowledge of Chemistry and related sciences.
3. Describe the significance of pH in household applications and environmental impact.
4. Develop scientific attitude to make the students open minded, critical and curious.
5. Examine chemical processes in household products and their impact on health and the environment.

Course Learning Outcomes:

On successful completion of the course students will be able to

CLO1: Recall common chemical concepts and terminology used in daily life.
CLO2: Explain how chemical processes affect various aspects of daily life, such as health, environment, and technology.
CLO3: Analyze the impact of chemical processes on society, the environment, and industry.
CLO4: Evaluate the safety and ethical considerations associated with the use of chemicals in everyday life.

MODULE I: Applications, Uses and Impact of Chemistry 15 Hours

Pharmaceuticals- Historical developments in medicine, Contribution of chemistry to human health, Classification of drugs and some common drugs used in our daily life.
Plastics and Polymers - Introduction, types of polymers, Plastic in daily use: HDPE, LDPE, PVC, PET, PP. Environmental Hazards of plastics, Biodegradable plastics.
Cosmetics - Basic concepts-composition and classification of creams-sunscreen and suntan Lotions, deodorants, talcum powder- Identifiers, lipsticks, oils, face creams, skin products, dental cosmetics, hair dyes, shaving cream, shampoo.

MODULE II: Impact Of Chemistry in Other Fields 15 Hours

Chemistry & Art – History of colour, Use of colour to decorate the body and surroundings. Relationship between light and colour. Electromagnetic Spectrum, Cause of colour in objects, Properties of Light.
The Nature and behaviour of light, mixing colours: Light vs. Pigments, Colorants: Pigments and Dyes. Chemistry of art conservation and restoration, Fakes and Forgeries in art.
Chemistry and Sports - Chemistry of sports materials, Use of performing enhancing drugs in sports
Gobar gas: Production, feasibility and importance of Biogas with special reference to Rural India; Fertilizers: Definition, classification - Urea, NPK and Super phosphates, uses and hazards.

REFERENCE BOOKS:

Mandatory:

1. Singh, K. (2012). Chemistry in daily life. PHI Learning Pvt. Ltd.

Supplementary:

1. Chemical Process Industries - Norris Shreve Joseph A. Brine. Jr.
2. Environmental Chemistry - A. K. DE.
3. Industrial Chemistry, B. K. Sharma- Goel publishing house Meerut.
4. Food Science - B. Srilakshmi - III Edition - New Age International Publishers, 2005.
5. Food Chemistry, Lillian Hoagland Meyer - CBS publishers & distributors, 2004.
6. Fundamental Concepts of Applied Chemistry - JayashreeGhosh, S. Chand & Co Ltd., New Delhi - 2010.
7. Applied chemistry - K. BagavathiSundari - MJP Publishers (2006). Course Materials

WEB REFERENCES

1. https://ncert.nic.in/ncerts/l/lech207.pdf
2. https://www.researchgate.net/publication/244480193_An_Introduction_to_Toothpaste_-_Its_Purpose_History_and_Ingredients
3. https://www.academia.edu/29067197/Plastic_pdf
4. https://www.susana.org/_resources/documents/default/2-1799-biogasplants.pdf

SEMESTER IV

DISCIPLINE SPECIFIC RESEARCH ELECTIVES (DSRE)

Course Code: PGMP-CHE-DSRE-504
Course Title: Synthesis of Inorganic Materials
Credit: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:
The course will enable the student to:

1. Define key terms and concepts related to reactions employed in synthesis, ceramic procedures, precursor methods, and various synthesis techniques.

2. Explain the principles and underlying mechanisms of various synthesis methods.
3. Describe the advantages and limitations of different synthesis techniques.
4. Apply the knowledge of synthesis methods to design and conduct experiments in the laboratory.

Course Learning Outcomes:
Upon successful completion of this course, the students will be able to:
CLO1: Recall and list the different precursor methods for material synthesis.
CLO2: Identify the principles and processes of combustion synthesis
CLO3: Explain the concept of intercalation chemistry and its significance in material synthesis
CLO4: Analyse the advantages and limitations of various synthesis methods in the context of material properties and applications.

MODULE I: Methods of Synthesis – I **15 Hours**
Introduction, reactions employed in synthesis, ceramic procedures, precursor methods, combustion synthesis, Intercalation chemistry, sol-gel synthesis, ion exchange method, co-precipitation.

MODULE II: Methods of Synthesis – II **15 Hours**
Electrochemical methods; nebulized spray pyrolysis; arc and skull methods; Reactions at high pressures; intergrowth structures; Metal borides, carbides, and nitrides; metal fluorides; metal silicides, phosphides, sulfides, and related materials.

REFERENCE BOOKS:
Mandatory:

1. Abbott, E. H., and Rao, C. N. R. (1995). Chemical Approaches to the Synthesis of Inorganic Materials.
2. Rao, C. N. R., and Biswas, K. (2015). *Essentials of inorganic materials synthesis*. John Wiley & Sons.

Supplementary:

1. Schubert, U. S., and Hüsing, N. (2019). Synthesis of inorganic materials. John Wiley & Sons.
2. Lalena, J. N., Cleary, D. A., Carpenter, E., and Dean, N. F. (2008). Inorganic materials synthesis and fabrication. John Wiley & Sons.
3. Van der Put, P. J. (1998). The inorganic chemistry of materials: How to make things out of elements. Springer Science & Business Media.
4. Sambandan, E. (2008). *Inorganic Materials Chemistry: General Concept and Research Topics* in Universe.

WEB REFERENCES
1. https://link.springer.com/chapter/10.1007/978-1-4899-0095-1_8
2. https://pubs.acs.org/doi/10.1021/jacs.1c04888
3. https://www.nature.com/articles/s41597-022-01317-2
4. https://www.mdpi.com/1420-3049/27/7/2045
5. https://par.nsf.gov/servlets/purl/10040699

Course Code: PGMP-CHE-DSRE-505
Course Title: Catalysis
Credit: 2
Duration: 30 hours
Maximum Marks: 50

Course Objectives:

The course will enable the student to

1. Define the general principles of catalysis.
2. Explain the thermodynamic considerations related to catalysis.
3. Identify various types of solid catalysts.
4. Compare and contrast monolayer and multilayer adsorption processes.
5. Apply knowledge of thermodynamics to assess the feasibility of catalytic reactions.
6. Analyse the kinetic mechanisms of catalytic reactions, including rate-determining steps and rate expressions.

Course Learning Outcomes:

On successful completion of the course, the student will be able to

CLO1: Explain the general principles of shape-selective catalysis and the various types of solid catalysts.

CLO2: Understand the thermodynamic considerations in catalytic reactions.

CLO3:. Compare and contrast different types of adsorptions mechanisms.

CLO4: Analyse catalyst preparation and deactivation methods.

CLO5: Perform catalytic reactions for various chemical transformations using suitable catalysts.

MODULE I: Fundamentals in catalysis **15 Hours**

Catalysis - general principle, thermodynamic considerations, types of solid catalysts, catalyst deactivation, types of adsorptions - monolayer adsorption, monolayer adsorption on homogeneous and heterogeneous surface; multilayer adsorption- polyani's theory of adsorption: adsorption on porous solids, catalyst texture, surface area - volumetric method, gravimetric method, flow method; pore size distribution- pore size from adsorption, mercury porosity meter, chemisorption - chemisorption of hydrogen, O_2, N_2 and CO, unsaturated hydrocarbons, chemisorption bond-covalent bond, ionic bond, quantum mechanical approach participation of d electrons.

MODULE II: Reaction kinetics and role of Catalyst **15 Hours**

Reaction kinetics- the rate determining step, rate expressions, geometric factor in catalysis balandin'smultiplet theory, electronic effect in catalysis by metals, band theory, pauling's valence bond method, electronic structure and catalysis. catalysis by semiconductors; boundary layer theory of chemisorption, catalysis by acidic solids, zeolites – structure, zeolite pores, synthesis, acidity of zeolites, shape selective catalysis, zeolite based processes, aluminophosphate molecular sieves, clays- intercalation of clays, pillared clays, catalysis with clays, mesoporous materials, preparation of catalysts precipitation method, impregnation method, role of support, loading of the support, microporous solids- mesoporous solids role of diffusion.

REFERENCE BOOK:

Mandatory:

1. D. K. Chakrabarty and B. Viswanathan, Heterogeneous Catalysis, New Age International Publishers, 2008.

Supplementary:

1. G. A. Somorjai, *Introduction to Surface Chemistry and Catalysis*, John Wiley, 2002
2. M. Thomas and W. J. Thomas, Principles and Practice of *Heterogeneous Catalysis*, VCH Publishers, 1996.
3. Bhatnagar, M. S. (2004). *A Textbook of Polymer Chemistry*. S. Chand Publishing.

4. Shelef, M., and Otto, K. (1971). *The theory of adsorption and catalysis*: By Alfred Clark, Academic Press, New York

WEB REFERENCES:

1. https://www.britannica.com/science/catalysis/Classification-of-catalysts
2. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.)/14%3A_Chemical_Kinetics/14.07%3A_Catalysis
3. https://www.sciencedirect.com/topics/engineering/catalyst-preparation
4. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Principles_of_Modern_Chemistry_(Oxtoby_et_al.)/Unit_5%3A_Rates_of_Chemical_and_Physical_Processes/18%3A_Chemical_Kinetics/18.7%3A_Kinetics_of_Catalysis
5. https://www.britannica.com/science/silicate-mineral
6. https://www.explainthatstuff.com/zeolites.html

Course Code: PGMP-CHE-DSRE-506
Course Title: Applied Organic Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objective:

The course will enable the student to

1. Recall and define key terms related to retrosynthesis, such as synthons, synthetic equivalents, and disconnection approach.
2. Comprehend the principles of retrosynthetic analysis, including how to perform one-group and two-group C-X disconnections for aromatic compounds.
3. Understand important strategies for amine and alkene synthesis.
4. Develop synthetic routes for complex molecules using retrosynthetic principles, including the selection of appropriate protecting groups and chiral reagents.

Course Learning Outcomes:

By the end of this course students will be able to, the student will be able to

CLO1: Recall the fundamental principles of retrosynthesis, including the concept of synthons and synthetic equivalents.

CLO2: Understand the disconnection approach in retrosynthetic analysis and its application in the synthesis of aromatic compounds, amines, and alkenes.

CLO3: Analyse protection and deprotection methods as well as chemo and regioselective protection techniques. for various functional groups,

CLO4: Apply important strategies of retrosynthesis for the synthesis of organic compounds and their interconversions.

MODULE I: Retrosynthetic Analysis and Protecting Group 15 hours

Basic Principles and Terminology of retrosynthesis: Introduction to synthons and synthetic equivalents, disconnection approach, synthesis of aromatic compounds- one group and two group C-X disconnections, Amine and alkene synthesis- important strategies ofretrosynthesis, functional group interconversions, functional equivalents and reactivity-Umpolung reaction, Protection and deprotection of hydroxyl, carbonyl and amino groups, Chemo and regioselective protection and deprotection, common protecting groups used in Peptide synthesis.

MODULE II: Asymmetric Synthesis **15 hours**

Introduction, enantiomeric and diastereomeric excess- determination, distereoselectivity and enatio-selectivity in cyclic compounds, Cram's rule, FelkinAnh Model, Cram chelate model, stereoselectivealdol reaction, asymmetric induction- use of chiral auxiliaries, Chiral reagents and catalysts, asymmetric hydrogenation, epoxidation and dihydroxylation.

REFERENCE BOOK:

Mandatory:

1. Organic Chemistry, Jonathan Clayden, Nick Greeves and Stuart Warren

Supplementary:

1. R.O.C Norman and J.M Coxon, Principles of organic synthesis, 3rd ed. Blackie Academic & Professional, 1993.
2. J. March, Advanced organic Chemistry: Reaction Mechanism and Structure, 5thed, New York: John Wiley, 1999.
3. M.B. Smith, Organic Synthesis, McGraw Hill international Edn, 1994.
4. S. Warren, Organic Synthesis, The disconnection approach, John Wiley & Sons, 2004
5. P. Wyatt and S. Warren, Organic synthesis strategy and control, Wiley, 2008

WEB REFERENCES

1. https://www.khanacademy.org/science/class-11-chemistry-india/xfbb6cb8fc2bd00c8:in-in-organic-chemistry-some-basic-principles-and-techniques
2. https://themasterchemistry.com/fundamental-principles-of-organic-chemistry/
3. https://leah4sci.com/organic-chemistry-retrosynthesis/
4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/13%3A_Polyfunctional_Compounds_Alkadienes_and_Approaches_to_Organic_Synthesis/13.10%3A_Protecting_Groups_in_Organic_Synthesis
5. https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/asymmetric-synthesis
6. https://www.britannica.com/science/asymmetric-synthesis

Course Code: PGMP-CHE-DSRE-507
Course Title: Nanomaterials
Credit: 2
Duration: 30
Maximum Marks: 50

Course Objectives:

The course will enable the student to

1. List and describe the four generations of Nanoproduct development.
2. Explain the concept of Phase transition in nanomaterials.
3. Describe the various manufacturing processes for integrating nanoparticles into nanoproducts.
4. Apply knowledge of magnetization processes in nanoparticles and their role in nanomaterial properties.
5. Demonstrate an understanding of the self-assembly of nanomaterials at macroscopic scales and fabrication techniques.
6. Analyse the various applications of nanoparticles in different fields.
7. Examine the nature of nanoparticles in the environment, including exposure, effects, and risk assessment.

Course Learning Outcome:

By the end of this course students will be able to
CLO1: Memorize the fundamental properties and four generations of nanoproduct development.
CLO2: Study the concept of nanocomposites and their applications.
CLO3: Apply knowledge of nanoparticle properties to predict their behaviour in various applications
CLO4: Analyse the phase transition of nanoparticles and the methods for making nanostructures using top-down techniques.

MODULE- I: Nanoscale Materials 15 Hours

Introduction, Properties; Fundamental importance of size and its influence; Nanoparticles in the Atmosphere and Space, Phase transition, Manufacturing Processes: four generations of Nanoproduct development; integrating nanoparticles into nanoproducts, Types of nanomaterials Titanium dioxide, Zero-valent iron, carbon nanostructures- carbon black, carbon nanotubes, carbon nano-horns, fullerenes; composites and nanocomposites
Magnetism in Nanoparticles-Magnetisation Processes in Nanoparticles, Self-Assembly of Nanomaterials at Macroscopic Scales- Fabrication of Nanomaterials ,2D and 3D Nanomaterial Structures. Making Nanostructures Using Top-Down Methods, Applications of nanoparticles.

MODULE II: Environmental Fate and Transport of Nanomaterials 15 Hours

Nature of nanoparticles in the environment-Exposure, Effects and Risk, Predicting the behavior of Nanomaterials, Treatment of Nanoparticles in wastewater- Treatment Processes, Factors that affect the toxicology of Nanomaterials- Exposure and effects, Nanoparticles use in Pollution control, Atmospheric Nanoparticles-Sources and sinks; Health effects; New Particle formation and growth in the atmosphere, Measurement of Aerosol nanoparticles.

REFERENCE BOOKS:

Mandatory:

Nanotechnology and the Environment, Kathleen Sellers, Christopher Mackay, Lynn L. Bergeson, Stephen R. Clough, Marilyn Hoyt, Julie Chen, Kim Henry, Jane Hamblen, First Indian Reprint, 2012

Supplementary:

1. Introduction to Nanoscience and Nanotechnology, Chris Binns, John Wiley & Sons, 2010
2. Nanomaterials and Nanochemistry, Catherine Bréchignac, Philippe Houdy, Marcel Lahmani.
3. Nanoparticles in Medicine and Environment, Jan C.M. Marijnissen, Leon Gradoṅ, European materials research society.

WEB REFERENCES

1. https://www.emm-nano.org/what-is-nanoscience-nanotechnology/
2. https://pubs.acs.org/doi/10.1021/acsnano.5b01418
3. https://www.worldscientific.com/worldscibooks/10.1142/7364#t=aboutBook
4. https://www.nanowerk.com/nanotechnology-and-the-environment.php
5. https://www.opengrowth.com/resources/how-does-nanotechnology-impact-the-environment

Course Code: PGMP-CHE-DSR-501
Course Title: Dissertation
Credit: 16

Duration: 384 Hours
Maximum marks: 400

The dissertation must comprise of original research and may be conducted either at the Institute or with approval, in an outside institution or company e. g., the student's employers. The guiding teacher may serve some laboratory hours for industry work.
The dissertation work is to be submitted for: evaluation and Viva Voice examination at the end of Semester IV.
Written test must be conducted regarding the basic principles of techniques or instruments used with respect to the area of dissertation topic.
Students may be assessed based on designing the question bank by students on dissertation topic.

Course Code: PGMP-CHE-DSI-501
Course Title: Internship
Credit: 16
Duration: 384 Hours
Maximum marks: 400

MODULE A: Internship at Industry; Two weeks per Semester (Semester III and IV) **288 Hours**
MODULE B: Write up of the Internship work per Semester (Semester III and IV) **32 Hours**
MODULE C: Students to design four modules based on their experience at industry **64 Hours**